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MARINERS WEATHER Log

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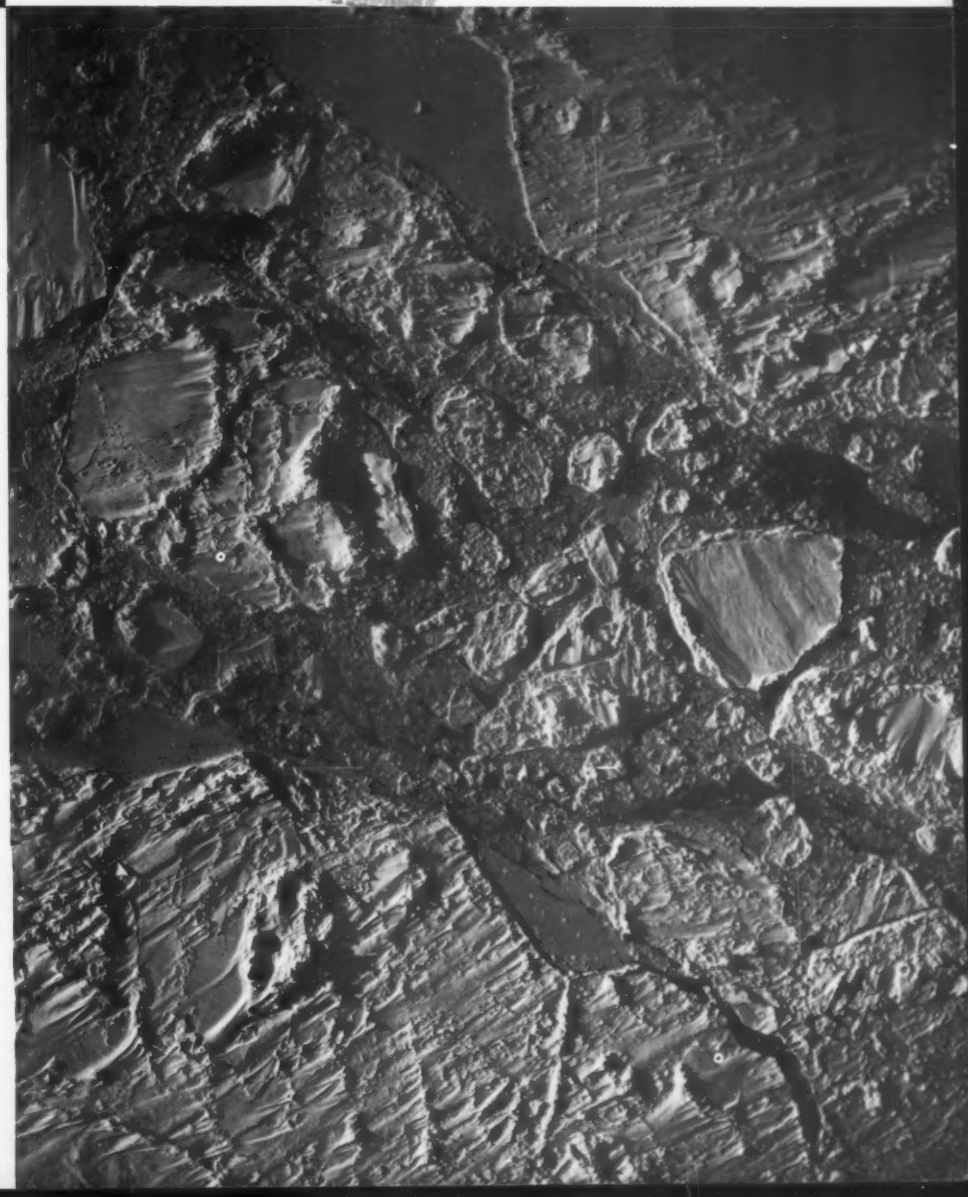

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MARINERS WEATHER LOG

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NOVEMBER 1973
VOLUME 17, NUMBER 6
WASHINGTON, D.C.

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Cover: Ice deformation, Denmark Strait, March 24, 1969. Photograph shows intensive compressive and tensile stresses and the results on the icepack. This is characteristic of the coastal ice of East Greenland. Here, alternate compressive and tensile deformation occur, caused by highly variable winds, long period swells, and greater ice speeds than anywhere else in the entire North American Arctic. See Part 2 of Sea Ice article on page 343.

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The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical approved by the Director of the Office of Management and Budget, July 26, 1973.

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MARINERS WEATHER Log

SEA ICE

Part 2 Ice Distribution and Forecast Services, North American Arctic Waters

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Washington, D. C.

and

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Editor's Note: This article on sea ice is being presented in a three-part series. Part 1 included background, history, and the major features and physical properties; it appeared in Vol. 17, No. 3 of the Mariners Weather Log. Part 2 is a discussion of sea ice distribution in North American waters, and forecast services. Part 3 will be a discussion of sea ice distribution and forecast services in Eurasian waters.

Some regimes of the navigable sea ice areas in the North American Arctic waters are subjected to total or near total annual growth and decay cycles; examples are the Baffin Bay and the Bering Sea icepacks. This means that much of the sea ice in this hemisphere is predominantly first-year ice and, except where salinities are low or under conditions of extreme pressure, they do not offer serious problems to ships with reinforced hulls or accompanied by icebreakers, during much of the year. On the other hand, several areas contain considerable quantities of multi-year ice, alternately advected into or away from an area; examples of this type are the Chuckchi and Beaufort Seas icepacks north of Alaska, the pack ice drifting southward off East Greenland, and that contained within portions of the Canadian Archipelago. However, in the Archipelago, it is more a matter of sea ice regularly surviving the brief summer melt season--

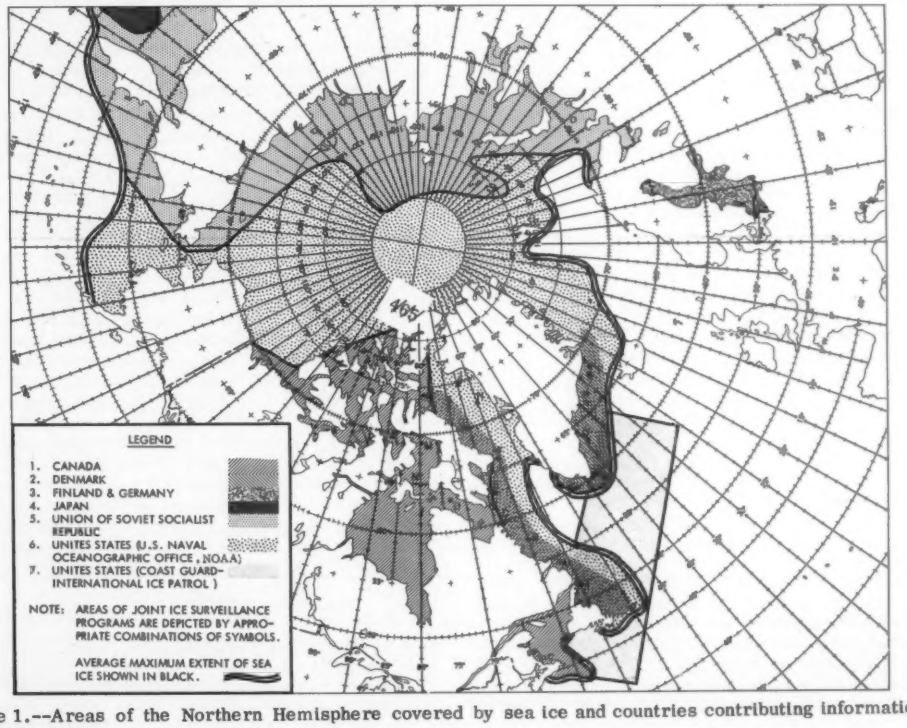

LEGEND
1. CANADA
2. DENMARK
3. FINLAND & GERMANY
4. JAPAN
5. UNION OF SOVIET SOCIALIST REPUBLIC
6. UNITES STATES (U.S. NAVAL OCEANOGRAPHIC OFFICE, NOAA)
7. UNITES STATES (COAST GUARD-INTERNATIONAL ICE PATROL)
NOTE: AREAS OF JOINT ICE SURVEILLANCE PROGRAMS ARE DEPICTED BY APPROPRIATE COMBINATIONS OF SYMBOLS.
AVERAGE MAXIMUM EXTENT OF SEA ICE SHOWN IN BLACK.

Figure 1.--Areas of the Northern Hemisphere covered by sea ice and countries contributing information to the ice program.

and being "trapped"--rather than one where continuous advective influences play the leading role.

Sea ice in the marginal seas of North America (fig. 1) usually forms first along the more northern coasts and in protected harbors and embayments, under the influence of polar outbreaks of cold air. The combination of winds, waves, tides, and currents break up much of the landfast ice and redistribute it in varying concentrations, or completely melt it, in coastal and near coastal waters, at the termination of the growth season. Considerable annual variability in ice extent occurs in most areas. The major deterrents to unreinforced vessels are usually the lingering coastal fast ice and pressure ice, which have moved into harbors and coastal localities. (Opening dates can be found published in the major atlases and ice bulletins of the various countries involved.)

Figure 2 is a locator chart for the geographical places discussed in the article.

MAJOR NORTH AMERICAN ICE REGIMES

BAFFIN BAY, DAVIS STRAIT, AND LABRADOR SEA

Thick, strong old ice is found in the northern part of the area and may on occasion drift southward. However, first-year ice occurs throughout most of the ice-covered portions of this area (fig. 3). Ice first appears in late October and early November in western Smith Sound and Davis Strait. It later spreads throughout Hudson Strait and along the southeast coast of Labrador. Freezing occurs along the coast of Labrador, along the north and east coast of Newfoundland, and in many of the Greenlandic fjords and northern coastal areas, by December. Sea ice generally forms

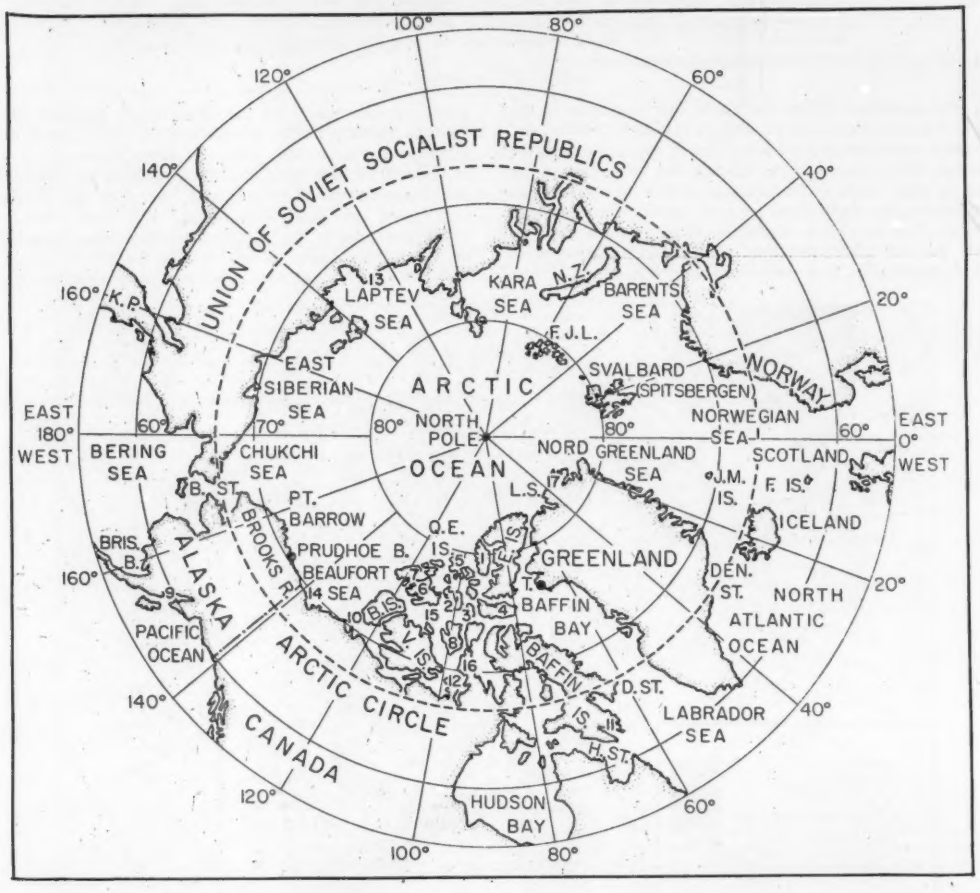


Figure 2.--Location chart for arctic ice areas. Key to place names follows: 1. Axel Heiberg Island; 2. Bathurst Island; 3. Cornwallis Island; 4. Devon Island; 5. Ellef Ringnes Island; 6. Melville Island; 7. Prince Patrick Island; 8. Prince of Wales Island; 9. Cook Inlet; 10. Franklin Bay; 11. Frobisher Bay; 12. King William Peninsula; 13. Lena River Delta; 14. Mackenzie River Delta; 15. Viscount Melville Sound; 16. Boothia Peninsula; and 17. Cape Morris Jesup.

Figure 3.--Heavily puddled first-year ice; this ice is snow-covered, considerably broken up with some open water in evidence.

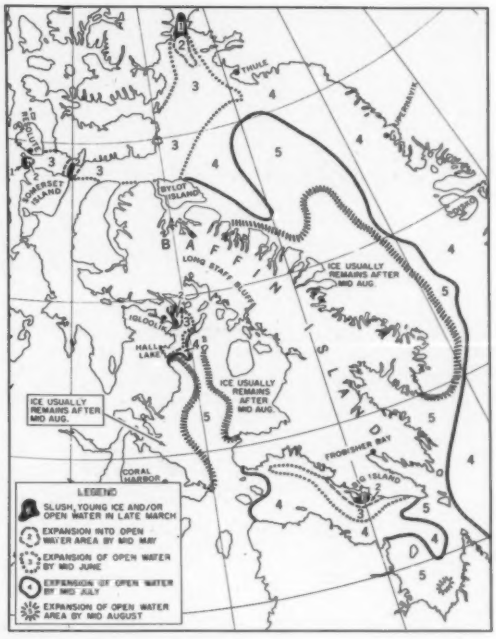

THULE
SOMERSET ISLAND
BYLOT ISLAND
BAFFIN ISLAND
LONG STAFF BLUFF
ICE USUALLY REMAINS AFTER MID AUG.
IGLOOLIK
HALL LAKE
ICE USUALLY REMAINS AFTER MID AUG.
ICE USUALLY REMAINS AFTER MID AUG.
FROBISHER BAY
CORAL HARBOR
LEGEND
SLUSH, YOUNG ICE AND/OR OPEN WATER IN LATE MARCH
EXPANSION INTO OPEN WATER AREA BY MID MAY
EXPANSION OF OPEN WATER BY MID JUNE
EXPANSION OF OPEN WATER BY MID JULY
EXPANSION OF OPEN WATER AREA BY MID AUGUST

Figure 4.--Pattern of breakup in Baffin Bay and portions of the Canadian Archipelago.

in the Gulf of St. Lawrence by late December or early January. By February, sea ice exists in concentrations of 6/8 to 8/8 throughout Baffin Bay, the western and northern Davis Strait, and to as much as 100 mi off the northern Labrador coast, decreasing in extent southward to Newfoundland, but expanding again, in extent, in the Gulf of St. Lawrence. Lesser concentrations of sea ice exist up to 200 mi off the Labrador coast, following the expanding flow of the Labrador current south to the Avalon Peninsula of Newfoundland. Beginning in May, the areas of sea ice cover have reached their maximum and begin to shrink by melt and decay (fig. 4). By June, Newfoundland is usually ice-free, and by August the Labrador coast and most of the west coast of Greenland are relatively ice-free. Mean maximum thickness ranges from 30 cm to 1 m in the south near Newfoundland, to 1 to 1.6 m near northern Labrador, and 1.6 to 2 m in the Davis Strait. Some thicker multi-year ice also is present along the Devon and Baffin Island coasts. Pressure ice in northern Baffin Bay, in ridge form, may attain a total thickness of close to 45 m on rare occasion. This area is also influenced by icebergs, most of which have their origin from the Greenland icecap. Because of their huge size, many of these bergs drift far south into major intercontinental shipping lanes before disintegrating.

HUDSON BAY AND HUDSON STRAIT

Although some multi-year ice generally remains in Foxe Basin to the north, the Bay and Strait have annual freeze and retreat cycles of sea ice. In October, ice forms in the north, and along the east and west coasts of the Bay. By November, the entire Bay and Hudson Strait contain varying amounts of sea ice, with fast ice forming along all coasts, and with concentrations ranging from 1/8 to 4/8 throughout the area. By December, concentrations generally reach about 4/8 throughout the area and, by January, with James Bay totally ice-covered, concentrations of up to 7/8 occur throughout most of the Hudson Bay. Such concentration occurs slightly later in the Hudson Strait, and these conditions persist throughout the entire area until early May, with considerable pressure ice prevalent. Decreases in concentration and melting occur along the coastal areas first, with high concentrations in the mid-Bay and mid-Strait, through mid-June. By July (fig. 4), concentrations decrease to 1/8 or less everywhere except in the middle Bay; and, by late August, the entire Bay and Strait are ice-free. Because of the size of the Bay and the Strait, and the influence of severe cyclonic storms, total coverage of solid ice generally occurs only along coasts and in the James Bay from December through early May. Mean maximum sea ice thicknesses vary from 1 to 1.3 m in the southern Bay, 1 to 1.6 m in the northern Bay, and 1.3 to 2 m in the Hudson Strait. In the Strait, severe tidal ranges (fig.5) of over 13 m occur. In addition, these areas experience frequent severe gales with their attendant strong variable winds. These factors, in combination with the many islands and shoals, create extremely severe ridging and ice deformation; this is especially true in the January through March period. Also, icebergs may intrude from the eastern mouth of the Strait west-northwestward to the vicinities of Big and Charles Islands.

Figure 5.--Grounded stamuhka (sea ice stranded on shoal or shallows) beached at low tide during DEWLINE resupply.

CANADIAN ARCHIPELAGO

Heavy arctic sea ice and local first-year ice are a major hindrance to shipping throughout the entire year; however, August and September may be regarded as a period of possible navigation, but only with icebreaker assistance. Frequent difficulties were encountered in the voyage of the MANHATTAN in 1969, despite its specially constructed hull and reinforcement. Except for the eastern Parry Channel and Jones Sound in the northern Archipelago, ice seldom breaks up completely. In the southwestern water bodies comprising this Archipelago, and in some of the channels leading into Barrow Strait and Lancaster Sound, it does break up to some extent during summer; remnants of thick, old ice rarely disappear completely. Elsewhere in the Archipelago, the ice "sets" or becomes landlocked late in December or in early January. Thereafter, it behaves much like fast ice until the summer breakup. Navigation, even with icebreaker assistance, is dependent upon the location of leads, rotten ice, and the avoidance of old pressure ridges and ridge fragments.

Resolute Bay, long the major weather and logistical base of operations, is usually accessible in July (fig.4). Mould Bay to the west and Eureka and Alert to the north, although sometimes inaccessible, can usually be reached in late August or September. Isachsen, or Ellef Ringnes Island, has never been reached by an icebreaker or reinforced cargo vessel. Late editions of the three-volume Canadian Arctic Pilot, issued by the Canadian Hydrographic Service, Department of Energy, Mines and Resources, provide especially good ice and environmental information, as well as marine operational information, in great detail.

CANADIAN ICE OBSERVING AND FORECASTING SERVICES

During the establishment of the northernmost United States-Canadian-Greenlandic weather stations in 1943-52, the establishment of Thule AFB in Greenland in 1951-52, and the DEWLINE stations in 1955-58, building materials, aviation fuel, and other energy resources were required in the ice-infested waters bordering Arctic Canada. This resulted in unprecedented logistical shipping into the area, largely in the form of icebreaker-escorted convoys. Offloading delays, while waiting for ports to become ice-free, and shipping damage sustained in transit and offloading dictated the development of aerial ice reconnaissance techniques. Also forthcoming were expanded understanding and predictability of the icepack and, finally, creation of formalized governmental services to perform these functions. The U.S. Naval Oceanographic Office, Washington, D.C., pioneered in such endeavors. As techniques became operational, the U.S. Naval Weather Service, in a planned transfer, took over the techniques, ice observer function, and training. By 1973, virtually all short (approximately 7 days) and longer term (30 days) ice forecasts, issued in support of U.S. military and scientific Arctic operations,

were being furnished by the Ice Services Department, Fleet Weather Facility, Suitland, Md. In the late 1950's, the Canadian Government sent scientific and technical personnel to the U.S. Naval Oceanographic Office to formally study methods and techniques employed in the observation (then primarily aerial) and the prediction of sea ice. Shortly thereafter, the Canadian "Ice Forecast Central" was established at Halifax, and W. Markham assumed a prime role in organizing and establishing this strictly Canadian Ice Forecast Service within the Meteorological Division of the Department of Transport, Canada.

By 1973, these Canadian sea ice services, continually expanding and becoming more proficient, were being provided under the Atmospheric Environment Service of the recently created Department of the Environment, Ontario, Canada; its Ice Central was moved to Ottawa. Outlooks (30-day) and shorter range ice forecasts are transmitted by publication, radio, and/or radio teletype, and sometimes by radiofacsimile format, on a regular basis during the operational season. At the end of each season, this activity issues publications describing that "ice year." Satellite data from conventional U.S. NOAA sources are utilized as imput data. Specially equipped Lockheed Electra L-188 C aircraft are, however, the basic ice-data-gathering mechanism. These aircraft are equipped with excellent navigation and remote sensors. During the operational season, field ice units for tactical support are established temporarily at Frobisher Bay, Resolute, and Inuvik. More definitive information on Aerial Ice Reconnaissance and Ice Advisory Services can be obtained from the Canadian Atmospheric Environment Service, Department of the Environment, 4905 Dufferin Street, Downsview, Ontario, Canada.

BERING SEA

This sea, together with contiguous portions of the Chuckchi to the north, is the shallowest of the North American Arctic Seas. The northerly currents through the Bering Strait generally prevent significant amounts of polar (multi-year) ice from penetrating the Bering Sea, which experiences an annual melt and freeze cycle of first-year ice. Sea ice first forms along the coast and in embayments, with earliest formation just south of the Bering Strait, in late September to mid-October. By late November, ice has formed as far south as the Kamchatka Peninsula in the west and the Alaska Peninsula in the east. As the season progresses, heavy concentrations of sea ice spread southward, reaching a maximum extent and concentration usually in March. Concentrations of 1/8 to 3/8 extend as far south as 60°N in the midsea, penetrating to the Alaska and Kamchatka Peninsulas in the east and west, respectively. Concentrations of 7/8 to 8/8 occur as far south as 60°N in the east and near 63°N in the west. Melting starts by May, with rapid decreases in ice concentration and melting of the landfast ice, especially in the south. By June, the ice has retreated to just south of the Bering Strait, and, by July, the Strait is open and the entire Bering Sea continues ice-free. Thicknesses range from 0.5 m in the south to less than 1.5 m near the Bering Strait, as an average seasonal maximum. Pressure ridges and rafted ice resulting from deformation processes, however, can result in ice draft of up to 12 m; and, on rare occasions in the northernmost portions of the sea, ice ridging up to 40 m draft can be encountered.

CHUCKCHI AND BEAUFORT SEAS

These seas are dominated most of the year by mixtures of first-year and old (polar) pack ice. The pack ice results, in significant part, from the predominant drifts of the Arctic Ocean ice circulation. August through October is the season of least ice, during which the northwest and north coasts of Alaska are relatively free of ice. However, the pack is seldom more than 10 mi offshore at that time. The existence of this open water along the coast is strongly dependent upon the strength and persistence of easterly and southerly wind components. Northerly and westerly winds generally force the floes against fast ice and toward the shore. By the end of September, new ice forms and sea ice begins its expansion southward, as ice from along the Siberian shore begins to drift southward to the Bering Strait. By October 10, shipping north of the Bering Strait is usually no longer feasible. Young ice forms north of the Bering Strait in October, when sporadic gales pile masses of ice on or close to the Alaska shore. By late October, the Bering Strait is closed with high concentrations of sea ice--a condition which persists until about late May of the following year, when the ice retreats northward into the Chuckchi Sea and coastal leads open again, mostly under the influence of the wind.

The most favorable route to the north coast of Alaska from the open Bering Sea for deep-drafted vessels of the future would be one that closely follows the International Dateline northward to the vicinity of Cape Lisburne. Beyond this point (at approximately 70°N), the quasi-permanent "flaw lead" or coastal lead (fig. 6), created by the predominantly offshore winds, usually approximating the 40 m isobath, would be considered as a most favorable route continuation to the Barrow vicinity.

Because of the petroleum, gas, and other resource

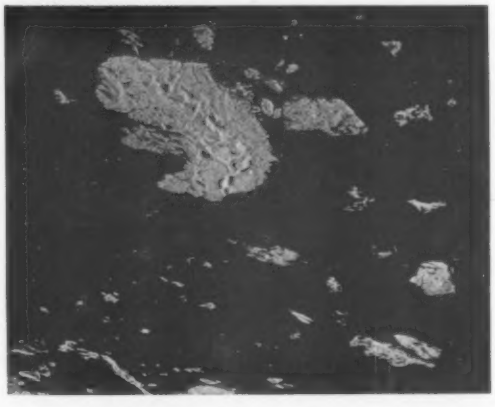


Figure 6.--Disintegrating multi-year flow in the characteristic open water lead north of the Alaska coast. The light gray area adjacent to the ice, with the black water background, is indication of the underwater extension or "rams"; these projections present a special danger to surface ships, as they cannot be seen from water vantage points.

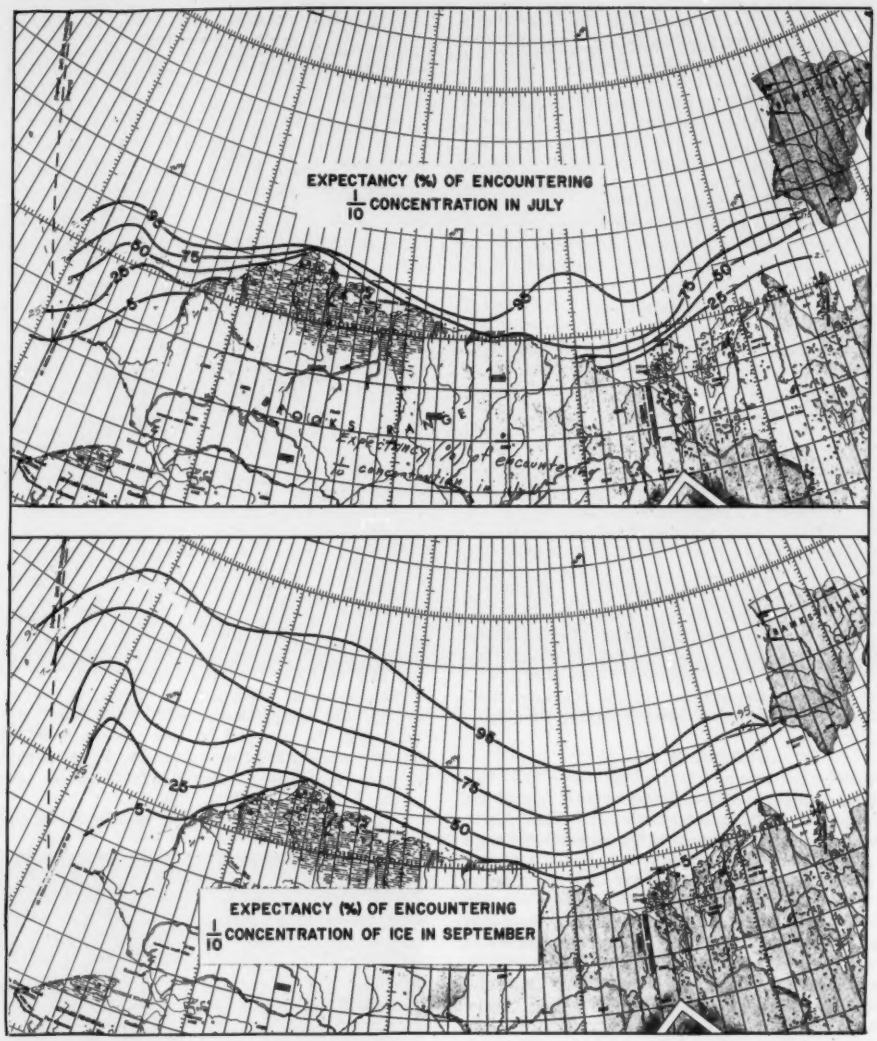


Figure 7.--Percentage frequency of 1/10 ice concentration in the Chuckchi and Beaufort Seas, July and September.

finds along the north slope of Alaska, the contiguous portions of the Chuckchi and Beaufort Seas are probably of greatest interest. Unfortunately, the ice regime here is probably at once the most complex and variable, from a daily, weekly, monthly, and annual point of view. Present-day icebreaker escorted convoys rarely can pass eastward of Point Barrow (fig. 7) before August 1. Along these northern coastal waters, shallows (18 m or less) extend from 10 to 40 mi seaward. In about one of seven summers, the ice is constantly impinging upon the shore. The main drift of polar ice is from north of the Queen Elizabeth Islands. This is the region of maximum ridging for the entire North American Arctic. Thus, periods of occasional persistent onshore wind drive this heavy, nonhomogeneous ice toward the shore, causing intensive and extensive deformation and grounding of the resultant ridges. Winds of gale force, though rare less than 100 mi seaward, frequently are experienced along the coastal zone, as shown in both Barrow and Barter Island climatic data. Thus, offshore drilling and the creation of terminal facilities for ships, harbors, and mooring facilities will be extremely difficult.

U.S. ICE OBSERVING AND FORECASTING SERVICES

In addition to initiating both the visual ice encoding, reporting, and training programs for ice observations

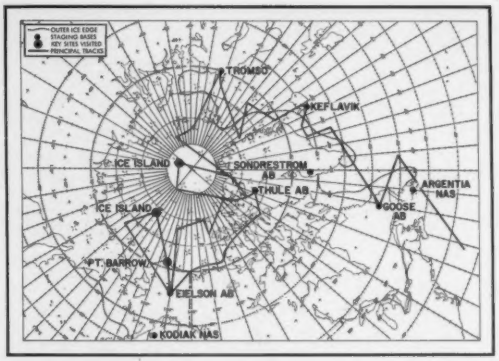


Figure 8.--Typical Project BIRDSEYE aerial ice reconnaissance tracks.

since the early 1950's, the U. S. Naval Oceanographic Office has passed over to the Naval Weather Service all its observing and ice forecasting functions in support of Department of Defense surface ship operations. Programs continued at the Naval Oceanographic Office are applied research, further development of observational techniques, formulation of manuals, production of ice atlases and special studies, and the issuance of certain long-range (30-day) outlooks.

By December 1, 1970, an Ice Services Department was established by the Naval Weather Service in the Fleet Weather Facility, Suitland, Md. Lt. Comdrs. W. Dehn and R. Freeman, two of the U. S. Navy's most experienced ice forecasters, play key roles in providing short and intermediate ice forecasts and advisory services. As of February 1, 1973, these services were as follows: Each week charts are disseminated, depicting observed ice conditions. Emphasis is on NOAA's Very High Resolution Scanning Radiometry (VHRR), and especially on Navy operational and Project BIRDSEYE reconnaissance flights (figs. 8 and 9). Ship and shore observations serve to augment the data base. Three charts describe the global scope; first, one for all of Antarctica; second, one for the eastern North American Arctic; and, finally, one for the western North American Arctic. Observed and forecast ice features on these maps consist of the ice edge and categorical concentrations expressed in octas of ice versus open water. The edge is predicted for a 7-day period. Verbal messages, sent to a wider distribution by radio dispatch, summarize this mailed product in order to facilitate its use.

Twice monthly, 30-day ice forecasts are sent in chart form and, only as the need arises, in radio dispatch form. Finally, on request, special operational messages are provided to Fleet and other activities concerned with ice conditions. Examples of users include the Military Sealift Command, U. S. Coast Guard icebreakers, and various foreign and U. S. Arctic research expeditions.

In addition to the U. S. Navy work in ice observing and forecasting, NOAA's National Weather Service, Anchorage Forecast Office, has recently entered the ice-forecasting field with its Regional Marine Forecasting (ice) activity in Alaska. In 1969, with the increased marine activity on the North Slope and elsewhere in the Alaskan region, the National Weather Service decided to become actively involved with ice prediction. By the summer of 1969, with Navy assistance, an ice forecast program had been set up, and

Figure 9.--The EC 121 Constellation Arctic Fox on a BIRDSEYE ice reconnaissance flight.

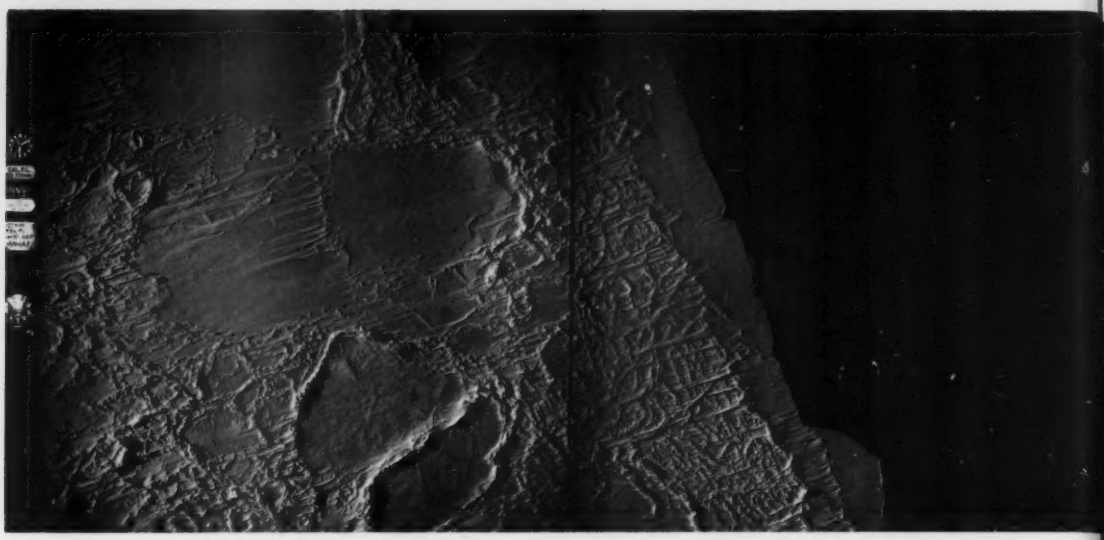


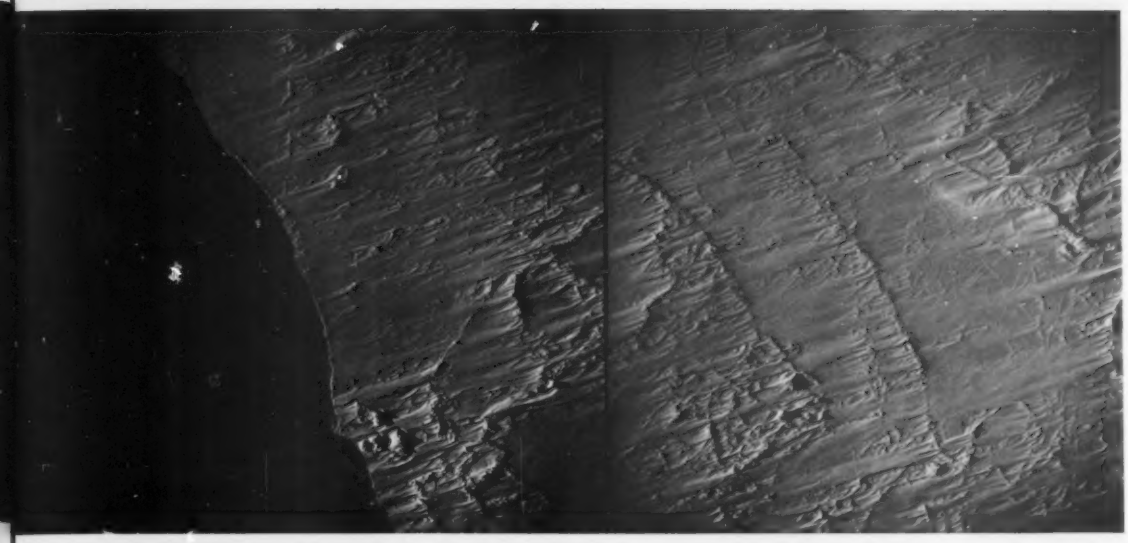
Figure 10.--Excellent adjacent photographs taken on BIRDSEYE flight of March 24, 1969, at 1810, showing alternate compressive and rarefying influence in the East Greenland Drift Stream. Note the evidence of severe recent wind by the lineations or "sastrugi" clearly evident downwind from the present ridges (and generally at right angles to them). Photographs were taken over the Denmark Strait at an altitude of 900 ft, near 67°15'N, 26°50'W.

sea ice became a part of a new marine forecast program by October 1969. This program has grown since that time, with the support and assistance from the Navy. L. Newman played a key role in its development.

At the present time, this activity issues twice daily advisories on ice conditions as a part of their marine forecasts; these reports are confined to the shipping season. By area, these reports cover the Arctic coastal waters bordering Alaska during late summer, and the Cook Inlet area during the sporadic freezeups occurring in the winter season. Features forecast include formation, general descriptive conditions, and breakup. Users include the companies drilling and moving oil in Cook Inlet and the greatly increased barge traffic to the Northern Slope; mining interests also make use of these products.

GREENLAND SEA AND DENMARK STRAIT

The currents and winds to the east of Greenland are effective in moving a great deal of polar ice and icebergs southward, especially during much of the year's winter season. The mean Icelandic low-pressure center is important as a driving force in this circulatory pattern. The Greenland and Iceland coasts adjoining the Denmark Strait southward are generally ice-free in late September and early October. By mid-October and November, old pack ice starts to move southward and new ice forms amongst the pack, as well as along the Greenland coast. New ice also begins to form in inlets and grow out from the coast in December, at which time the polar pack ice (to 7/8 concentration) begins to expand and strengthen in the Greenland Sea. This pack becomes mixed with first-year ice as it moves southward. This mixture results in part from a natural attenuation in the southward-moving ice; ice drift here increases in speed from mean daily rates of 6 mi per day in the Greenland Sea to 11 mi per day in the Denmark Strait. Through March and April, concentrations of 7/8 predominate midway between Greenland and Iceland (fig. 10), decreasing in extent southward, but with highly varying concentrations along the edge of the pack, depending upon the wind and current eddies (cover). By May, the pack again retreats, primarily through melting and by wave disintegration, especially in the more southerly regions. Concentrations decrease rapidly through June and July (generally 4/8 or less). Some limited amounts of ice, however, may spread to the north and east coasts of Iceland in severe years. The major pack width usually narrows at this time, so that by late August only a limited area along the Greenland coast west of Iceland has concentrations greater than 1/8. Mean maximum ice thickness of the first-year ice varies from 1.0 m near the southern coast of Greenland to about 1.0 to 2.0 m in the new ice northward along the Greenland coast west of Iceland. In the northern extremities of this southward-moving pack, off the coast of northern Greenland, thicknesses 2.0 to 2.5 m may be attained in the first-year ice. The old ice is 3.0 m thick in winter and decays to 0.5 m or so in summer and near the ice edge. Ridges here frequently reach 15 m, and, on rare occasions, 40 m and more. Icebergs also are frequently contained in the drift, but are usually confined fairly close to the coast by predominantly onshore winds and longshore currents.



By January, this East Greenland ice actually rounds Kap Farvel and continues to bother shipping for several hundreds of miles to the north-northwest, often until late March or April.

DANISH AND ICELANDIC ICE REPORTING SERVICES

The Danes established an aerial ice reconnaissance service in late 1959, after the tragic loss of the new ice-reinforced Danish ship HANS HEDTOFT earlier that year. The southern Greenlandic coastlines--both east and west--are surveyed throughout the year, but more frequently during the navigation season (April to August, inclusive). The surveillance does include, however, a few flights as far north as Nord, which was the northernmost North American land station, located on the East Greenland coast at approximately 83°N. This station was recently disestablished as a manned weather-reporting station. NOAA satellite data are also used to supplement the resultant charts, as are ship and shore ice reports. The ship ice reports are collected only in the navigation season, and are transmitted over radio stations in southern Greenland. The weather stations, spaced approximately 150 mi apart along Greenland's east coast, make frequent ice thickness measurements. All this air, ship, and shore information is incorporated, after analysis, into monthly summary charts under the publication title, "The Ice Conditions in the Greenlandic Waters." The first of these annual reports was issued in 1964; it is intended that this series will eventually be available for the years 1957 to date. Jens Fabricius and Hans Valeur have played the major roles in both formulation of the advisory services and issuance of annual reports. The reports are published through the Nautical Division, Det Danske Meteorologiske Institut, Charlottenlund, Denmark.

Icelandic governmental agencies have recently accelerated their interest in the East Greenlandic--and, indeed, global--ice distribution problems. With vigorous support from Director Hermannsson of their National Research Council, in 1971, they convened an international conference at Reykjavik; the resulting proceedings are available under the simple title, "Sea Ice." Perhaps the longest quasi-continuous records on regional sea ice data are held by the Icelanders, mainly from land station observations. Many of these data are available in various articles contained in their scientific periodical, Jökul. The Icelandic sea ice efforts are directed by H. Sigtryggsson, Director of the Icelandic Meteorological Office, Reykjavik, Iceland. Their present analyses and service include interpretation of satellite imagery, aircraft and ship reports acquired through the Icelandic Coast Guard, as well as the very comprehensive land station reports from their northern weather reporting network.

ST. LAWRENCE SEAWAY AND GREAT LAKES ICE DISTRIBUTION

Because of their southerly location, ice in these waters undergoes a complete annual cycle--forming initially in winter and disintegrating by early spring. The water is fresh except for the mouth of the St. Lawrence River and the St. Lawrence Gulf, and ice is frequently compressed shortly after it forms. Because of the relatively shallow depths, the continental exposure, and the generally severe storms of winter, these waters are subject to rapid changes in ice conditions and are seldom solidly covered. Winds and currents frequently create extreme concentrations, which inhibit surface shipping. Conditions may also vary considerably from year to year, depending upon the severity of the winter. Local ice conditions in channels and connecting waters are largely responsible for early restrictions to shipping.

In December, ice usually begins to form in the mouth of the St. Lawrence River, along the northern St. Lawrence Gulf and Belle Isle Strait. By January, all but the eastern Gulf has sea ice, with concentrations

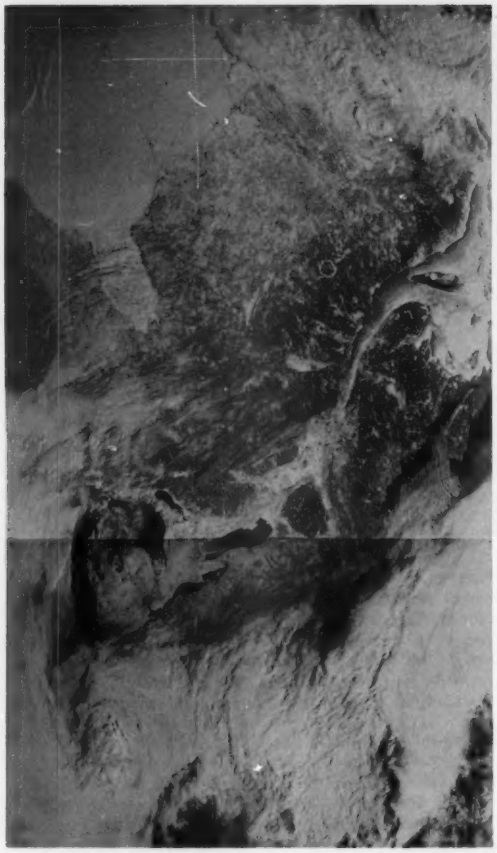


Figure 11.--NOAA-2 Very High Resolution Radiometer (VHRR) satellite photo, taken on February 28, 1973. It shows the St. Lawrence River and the Gulf of St. Lawrence almost completely covered with ice. At this time, ice on the Great Lakes reached its maximum coverage for the year, with Lake Erie and Lake St. Clair nearly frozen over. Hudson Bay is completely covered with ice.

of 4/8 in the central Gulf to 7/8 in the north and west and in the Belle Isle Strait. By February (fig. 11), the entire Gulf is under the influence of sea ice, with 7/8 concentrations everywhere except the eastern approaches through Cabot Strait, where concentrations may range from 1/8 to 4/8. By March, concentrations decrease along the flow patterns from the St. Lawrence River. However, concentrations remain high--7/8 or more--in the northeast (Belle Isle Strait approaches) and in the southwest. By April, concentrations rarely exceed 4/8 and, by the end of May, ice has disappeared everywhere except around Prince Edward Island and the Belle Isle Strait. Thicknesses generally vary from 0.5 to 1 m, with greater thicknesses, usually a result of wind action, sometimes occurring in the Belle Isle Strait and the mouth of the St. Lawrence.

In Lake Superior, the largest and deepest of the lakes, initial formation starts along the north and western shores, about mid-to-late January, eventually covering the perimeter and reaching maximum concentrations of about 5/8 to 7/8 by late March to early April. The east central part of the lake is generally ice-free, except during severe winters. Decay starts in early April and proceeds quite rapidly throughout the lake.

First formation in Lake Michigan occurs in the northwest in late January to early February, with the Straits of Mackinac (fig. 12) in the northeast waters the next to freeze. Formation then proceeds around the perimeter, with maximum concentrations of 6/8 to 7/8 by mid-to-late March, but with the central and south central lake generally ice-free. Decay generally begins in the south in late March and proceeds northward quite rapidly.

Lake Huron generally experiences first ice formation in Georgian Bay, near Mackinac Straits, and in the southern shallow water extremes during late January and early February. Perimeter freezing proceeds until late March, when concentrations of 4/8 to 7/8 are common, but with the central lake ice-free. Decay normally begins in the south of the lake during late March and proceeds northward.

Lake St. Clair, which lies between Lake Huron and Lake Erie, is very shallow and starts to freeze in early January, reaching 8/8 coverage by late January, and starting to decay by late February to early March.

Lake Erie, the shallowest of the Great Lakes, reacts rapidly to seasonal temperature changes. Ice forms first, in mid-to-late January, in the west and behind Long Point in the east. By late February, the lake is generally totally ice-covered. Decay generally begins in late February or early March, with ice clearing rapidly, except for concentrations in the east near Buffalo which result from wind and current action.

Ice in Lake Ontario is slow to form because of the lake's great depth. First formation occurs in late January to early February, in the shallow approaches to the St. Lawrence River in the northeast. The freezing pattern proceeds slowly, with maximum concentrations of 6/8 to 7/8 by mid-March, which rarely, if ever, affect more than the northeast third of the lake.

ICE FORECASTING SERVICES FOR THE ST. LAWRENCE SEAWAY AND GREAT LAKES

Because of the southerly location and early ice decay of the St. Lawrence Seaway and Gulf, and because of their importance in linking Canada's economy to the sea, the earliest spring ice forecast efforts of Canada's Ice Central are concentrated on the St. Lawrence Gulf and Seaway leading to the Great Lakes.

Ice forecast services on the Great Lakes are provided by NOAA's National Weather Service Office in Detroit, under the guidance of C. R. Snider. The Great Lakes ice observation program is the oldest in the nation, with earliest observations made about the beginning of the 19th century. In the mid-19th century, this service became formalized under the Army Signal Service and, by 1890, observations and forecasts were published. Efforts during World War II were aimed at extending the navigation season. This was considered on a scientific basis from 1950; and, several years ago,

Figure 12.--The ENDERS M VOORHEES transits the ice-covered Straits of Mackinac, one of the vital areas that usually freezes by February.

the emphasis was placed on a permanent extension of the navigation season.

Ice analyses are produced on alternate days by the NOAA National Weather Service at Detroit and by the U. S. Coast Guard at Cleveland. Each produces and exchanges three charts weekly. Two teletype messages are produced daily: the morning message is a long-range outlook (2 days to a week), while the afternoon message is a 24-hr outlook. The messages are disseminated to the news media as well. The major users are shipping, fisheries, recreation, transportation (ice barges to islands), and weather forecasters (as a feedback). The data used daily are observations from Coast Guard stations, ship reports, weekly aerial ice reconnaissance, satellite imagery, and environmental information. No special requests are filled; however, every attempt is made to provide the essential data to the major users on a regular basis. Regular NOAA liaison with the Coast Guard is aimed at assuring that operational needs are met. The NOAA activity prepares an annual summary of conditions each year, which is published in the Mariners Weather Log.

ICEBERG DISTRIBUTION AND REPORTING SERVICES

ICEBERG DISTRIBUTION AND FREQUENCY

According to the USCG, approximately 100 tidewater glaciers exist along the west coast of Greenland; about 20 are the principal producers or "calvers" of bergs that ultimately reach the North Atlantic shipping lanes. These are located in Umanak Fjord, Disko Bugt, and in the Thule approaches. The bergs are believed to travel about 1,800 mi before they reach the Grand Banks commercial shipping lanes. The many forces in the source region which cause calving, such as atmospheric warming, annual snow accumulation versus melt balance, and diastrophic activity, are ill-understood. We do know that very great annual variability occurs in the quantities moving south of 48°N. The month of greatest frequency is April; the season itself generally extends from March through July. Occasionally, however, bergs have been sighted in the shipping lanes in all seasons of the year. Bergs may reach heights of 100 m above water level; breadth of their irregular forms can be some 400 m. Thus, a single berg may represent 1.5 million tons of ice. Some bergs drift southward along the East Greenland coast. Most, however, are found in the Baffin Bay-Labrador Sea region. Little numerical data exist with regard to the East Greenland icebergs.

ICEBERG REPORTING SERVICE

Since 1914, the International Ice Patrol has been operated and managed by the U. S. Coast Guard. Its base of operation is Governors Island, N. Y. The prime function is to prevent a recurrence of the TITANIC disaster of 1912. In other words, the patrol observes and disseminates to international shipping

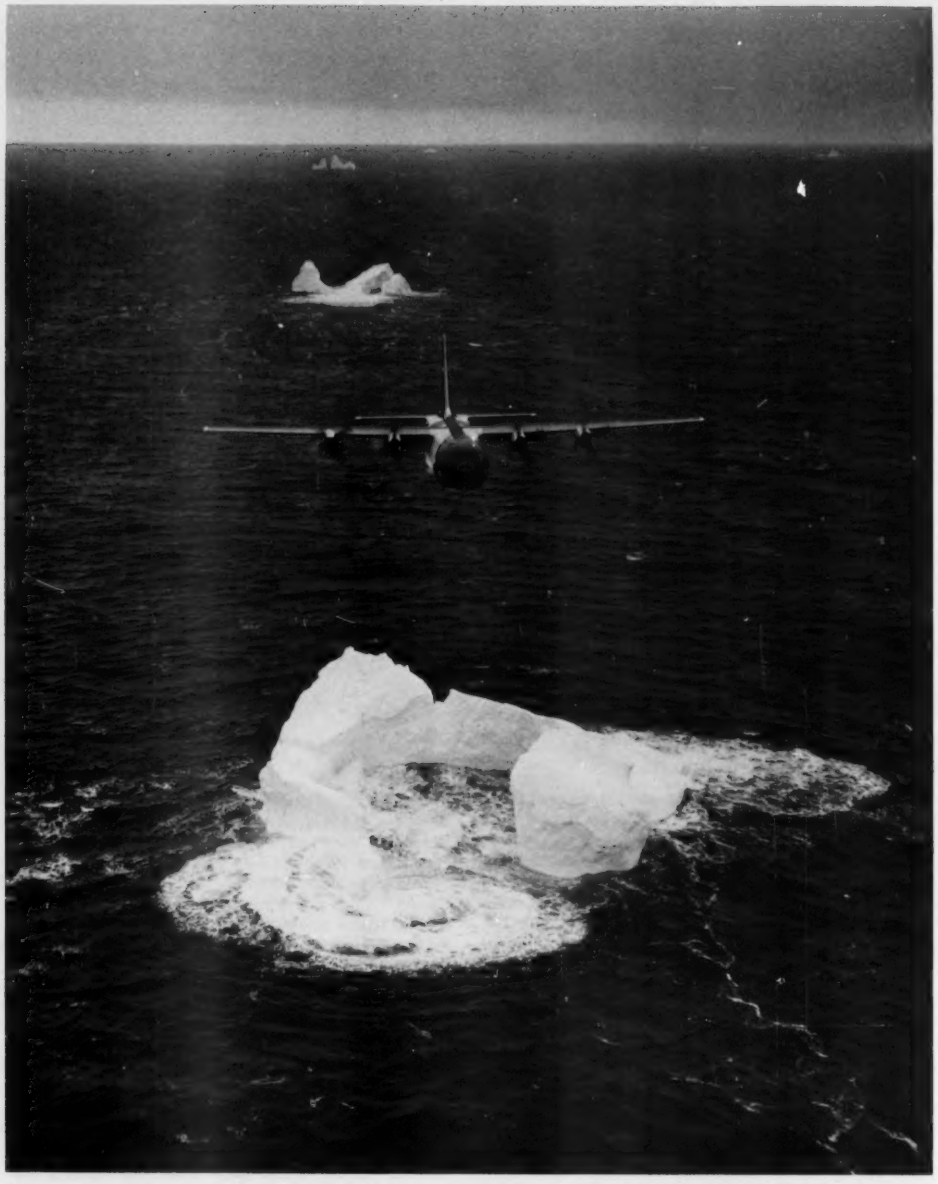


Figure 13.--The Coast Guard keeps a watchful eye on icebergs threatening North Atlantic shipping lanes. Here a reconnaissance plane is hedge-hopping a row of bergs off the coast of Labrador.

all possible documentation on the location, movement, and extent of icebergs and sea ice menacing the major North Atlantic shipping lanes. Although satellite imagery is utilized, Coast Guard cutters and merchant ships also play a major reporting role. Prime surveillance, however, is by USCG patrol aircraft (fig. 13). Surveillance is conducted three times weekly over an ocean area covering approximately 33,000 sq mi. The onset of the season depends on the wide annual variability in the number of icebergs occurring. The 1973 season was inaugurated on February 1, 1973. The patrol suspended operations on July 31 this year after having tentatively recorded 847 bergs, as compared with a mean of about 400, a minimum of 0, and a maximum of 1,600 in 1972. The counts represent the number of icebergs moving

Figure 14.--Alaska North Slope oil well #1 at Prudhoe Bay. Exxon Photo.

southward below the 48th parallel in a year.

Bulletins are broadcast regularly over established radio frequencies from Boston/NIK and St. Johns Nfld/VON. In addition, broadcasts are regularly issued by the Canadian Maritime Command COVE/CFH and the U. S. Naval Radio Station, Washington/NSS. The Boston station provides some voice broadcasts as well as facsimile transmissions. The newly created Defense Mapping Agency, Hydrographic Department, Washington, D. C., is charged with disseminating information on icebergs in the offseason. The International Ice Patrol summarizes all ship, related oceanographic survey, and other selected information in a series of publications entitled, "Report on the International Ice Patrol Service in the North Atlantic Ocean," for each year.

USERS: PRESENT AND FUTURE

To date, surface shipping in the North American Arctic has been the prime consumer of ice distribution data and forecast services. During a major portion of the year, icebergs determine the northernmost major shipping tracks between North America and Europe. Military and scientific expeditions have required ice information enroute to northern logistical bases. They have also served as major platforms for the conduct of air-ice-ocean research. With recent oil (fig. 14) and natural gas finds in the North American Arctic, this is now changing. This development and exploitation has required consideration of vastly improved ship designs for ice penetration (MANHATTAN voyage, 1969, fig. 15), as well as the formulation of engineering concepts for underwater pipelines and terminals that will withstand the scouring and crushing forces of glacial and sea ice.

Thus, the trend of this and future decades seems to be away from military and toward commercial utilization. This trend toward rise of resources is creating problems in environmental pollution and ecological disturbance. It has ushered in, on the other hand, a period of international scientific cooperation in the Arctic regions unparalleled in modern history. In February 1973, for example, the United States and the U. S. S. R. cooperated more fully than ever before in a joint scientific study of air-ice-ocean processes in the Bering Sea. The future for the North American Arctic seems certain to demand more such cooperative efforts, in order to adequately understand the basic problems associated with global heat balance and circulation, both in the atmosphere and within the oceans.

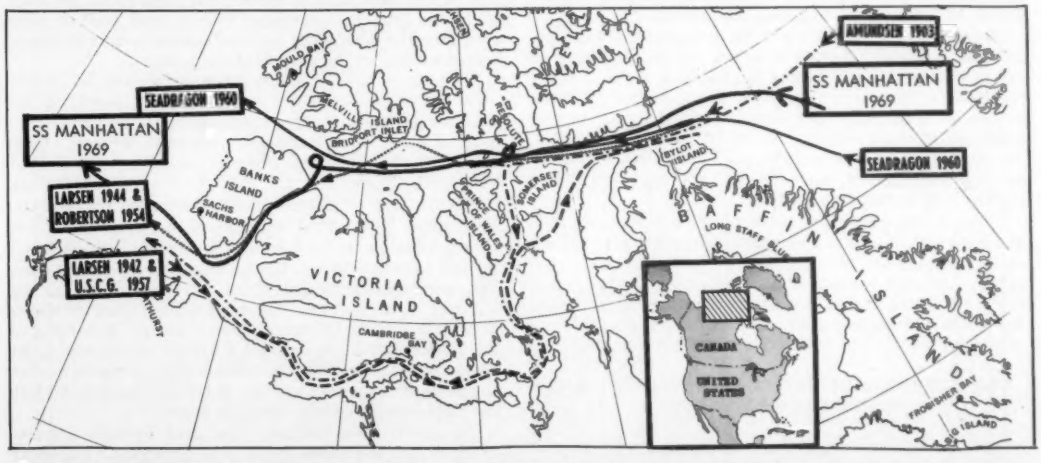


Figure 15.--Some classical tracks through the various "Northwest Passage" routes. Amundsen's voyage was in GJOA; Larsen's, in ST. ROCHR; Robertson's, in HMCS LABRADOR. The MANHATTAN voyage in 1969 was conducted under the overall leadership of Mr. S. Haas of Exxon Corp.

OCEAN CURRENTS AND COASTAL CLIMATES

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All mariners know that major currents stretch across the various oceans, but how many know that the ocean current affects the everyday navigation of his ship and the length of his very life? To be sure, this effect is indirect, but, indirect or not, the ocean current is an ever-present threat to the mariner. Ordinary storms have become monsters, carrying high winds and large sea and swell, after embedding themselves in the air over a warm ocean current. Visibility is often lowered to zero when a ship cuts through the meeting grounds of cold and warm currents.

An ocean current can bring warmth or chill, rain or aridity. A current can play havoc with marine forms, as South America's El Niño occasionally does, or it can be a cherished gift of life and beauty, like the warm waters of the Gulf Stream reaching outward toward northwestern Europe.

Some ocean currents exist because of the earth's climatological wind systems. Bounded by the configuration of the land, however, the tracks of all ocean currents are more or less fixed. Winds can blow from the sea to the land with only a minor deflection, but a wind-driven current must turn from the land and follow a coastline until directed to do otherwise by a change in the overall wind regime.

Temperature and salinity density differences also play a role in the development and maintenance of currents. Temperature differences are caused by such physical processes as upwelling--the rising of water toward the surface from deeper subsurface layers. Salinity differences are often caused by varying evaporation rates over the oceans. For example, oceans beneath the dry subtropical Highs have a high salt content. These differences in density distribution affect the horizontal and vertical circulation of the oceans, inducing movement.

The general circulation of the oceans (fig.16) is also affected by depth, the degree of enclosure, the shape of ocean basins and submarine barriers, and the deflective force of the earth's rotation. These forces combine to drive the surface currents about 20° to 40° to the right (Northern Hemisphere) or 20° to 40° to the left (Southern Hemisphere) of the wind direction. When a current slows down, spreads out, and becomes shallower, it is renamed a drift.

The major currents carry warm water northward and cold water southward, enabling them to play a hand in heat transport between the Tropics and polar regions. About 20 percent of all north-south heat transport is handled in this manner. When compared with horizontal atmospheric transfer, however, the fraction of energy carried by ocean currents is small.

THE CURRENTS OF THE NORTH ATLANTIC AND NORTH PACIFIC OCEANS

It will be helpful in this study to discuss collectively North Atlantic currents and their North Pacific counterparts. Major emphasis will be placed on the North Atlantic currents, with important differences between the two cited where applicable.

Let us first consider the general distribution of ocean currents (figs. 17-20) in the Northern Hemisphere. Almost immediately, one sees the effect of the subtropical High on the currents of the North Atlantic and North Pacific Oceans. To a lesser extent, the effect of the Icelandic and Aleutian Lows can also be seen, but density distributions and the configuration of the land (e.g., Gulf of Alaska) also play a vital role here. Ocean currents contribute to cold weather on the east coasts of continents north of 40°N, especially in winter. On west coasts, mild weather is the rule. South of 35°N, however, the reverse is true. The east coasts of continents tend to be warm, and the west coasts cool, especially in summer.

Let us now take a look at the Gulf Stream system (including the Florida Current, the North Atlantic Current, and the Norwegian Coastal Current, and then discuss the Kuroshio Current and its extension, the Aleutian Current, and the Alaska Current.

The Gulf Stream system stretches from the Florida Straits, where its speed in some places exceeds 5 kt, northeastward to the Norwegian and Barents Seas. The resulting warm water off the coast of Norway produces the largest positive temperature anomalies in the world, when compared with average global temperatures at this latitude. For example, the coastal city of Bergen, Norway, has an average annual temperature of 45°F (7°C), while Ivigtut, Greenland, at about the same latitude and also facing a large body of water on its west, has an average annual temperature of 33°F (1°C). Other factors, such as the length of water that the westerlies have to pass over, also enter the picture, but the fact remains that a good part of this temperature difference is attributable to the relatively warm waters of the Gulf Stream system.

The projection of the northeastern coast of Brazil into the Atlantic Ocean a few degrees south of the Equator is the principal contributor to the great volume of water contained within the Gulf Stream. Part of the North Equatorial Current and about one-half of the South Equatorial Current (becoming the Guiana Current) are diverted northwestward by Brazil. The North Equatorial waters and the Guiana Current merge to become the Caribbean Current, which flows to and through the Caribbean Sea, the Yucatan Channel, and then out through the Florida Straits as the Florida Current. One hundred billion tons of water pass through these straits every hour. A portion of the broad North Equatorial Current approaching the Leeward Islands from the east follows a shorter route north of Hispaniola, as the Antilles Current, to join the Gulf Stream off the Florida coast.

As previously stated, the Gulf Stream system reaches into the Barents Sea, a polar region. The polar basin is supplied with large amounts of heat, enabling Norway to have ice-free harbors and the U. S. S. R. to

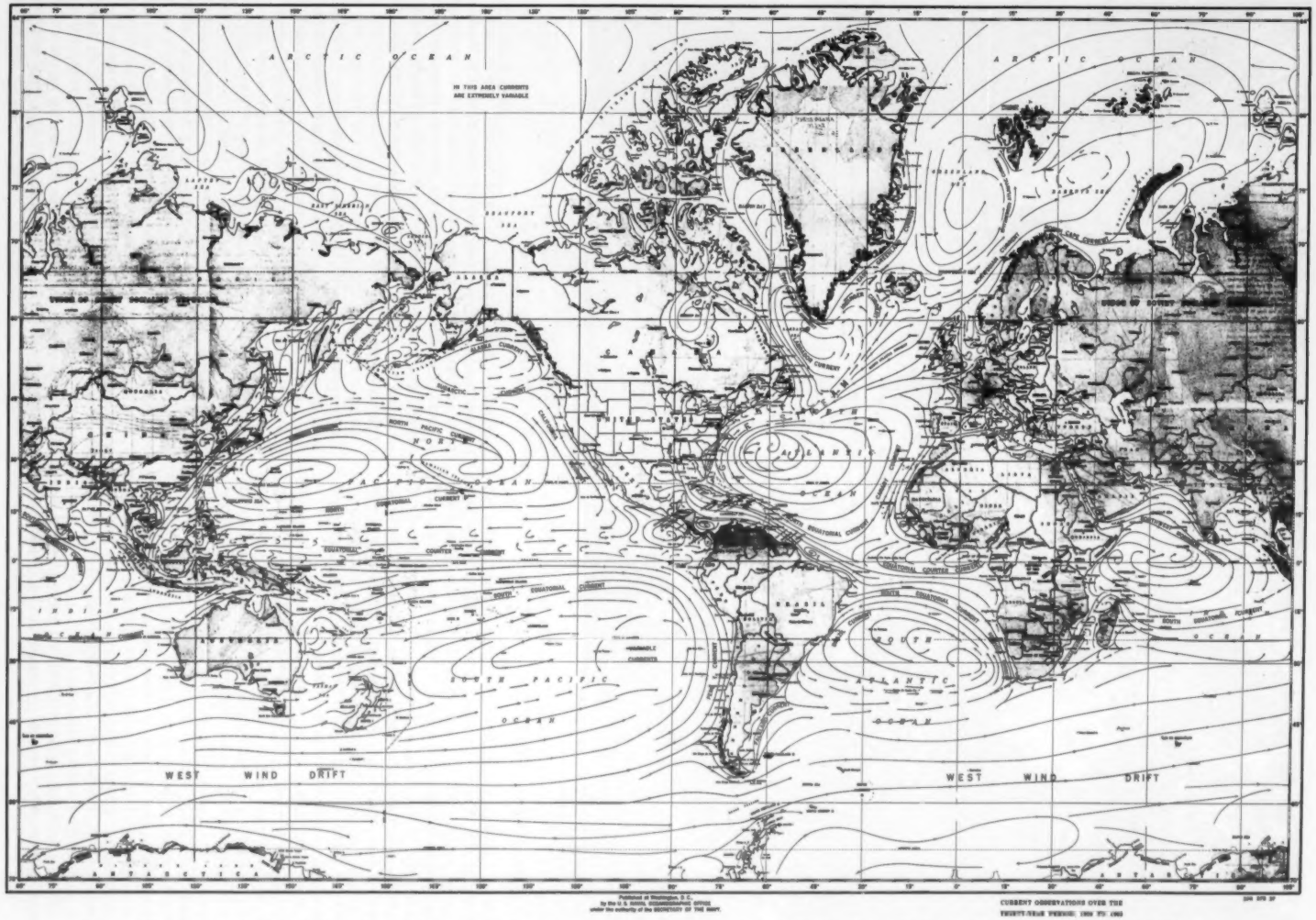

Figure 16.--General circulation of world ocean surface currents, July, August, and September. Defense Mapping Agency Pilot Chart.

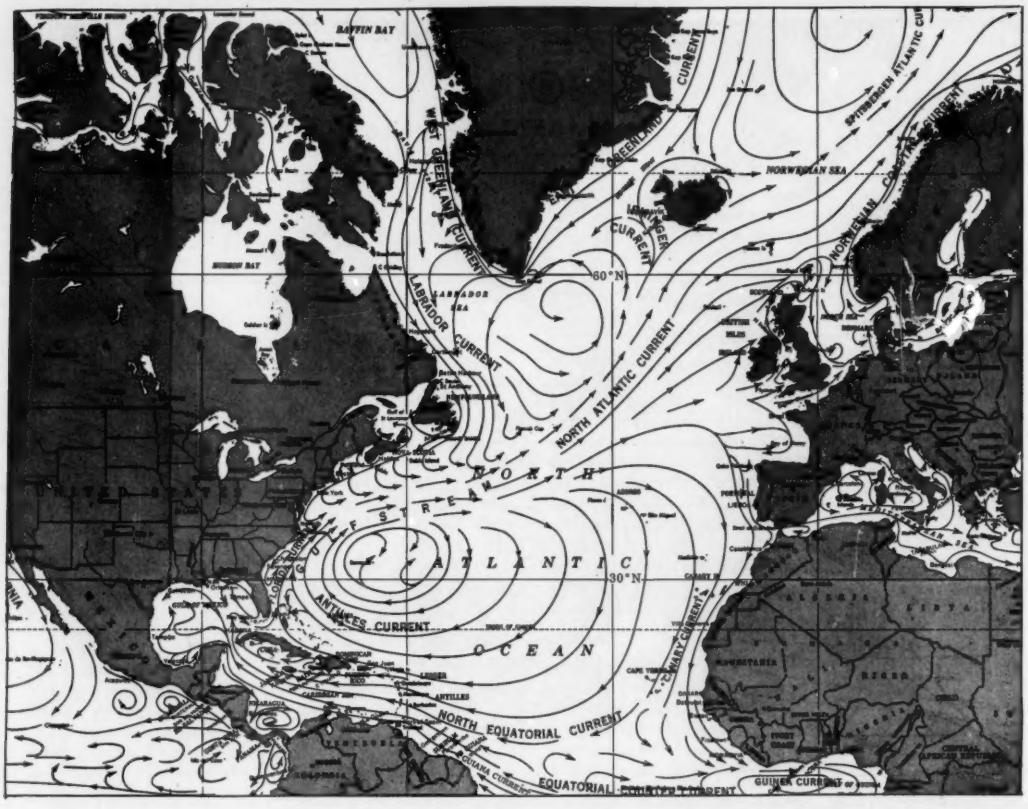

Figure 17.--General circulation of North Atlantic surface currents, January, February, and March. Defense Mapping Agency Pilot Chart.

have a relatively ice-free port (Murmansk, 150 mi north of the Arctic Circle), while Baltic ports are frozen solid. All of Scandinavia would not be free from permafrost at sea level without the presence of the Stream's warming influence. Because of the Gulf Stream, a greater depth of warm water is banked up against the shores of western Europe than anywhere in the Tropics. Many historians believe that without the Gulf Stream, civilization would not have spread as rapidly from southern to northern Europe.

The warm Gulf Stream is also a source of moisture for the East Coast of North America. Without it, many of the cyclones which are spawned off the Carolina coast would not be given life. If all other conditions are favorable, warm ocean currents can kick off cyclone development, especially in the fall and early winter months. Vertical motion (a forerunner of precipitation) accompanies a developing LOW, and easterly winds ahead of the storm pick up added moisture by blowing across the Gulf Stream (warm air has greater moisture-bearing capabilities than colder air) before striking land. Once born, these cyclones often follow the Gulf Stream toward Europe.

The Gulf Stream system is self-perpetuating for the same reasons as other large-scale wind-driven warm currents. The warmer surface waters induce lower pressures in storms, yielding climatological features such as the Icelandic Low. These more intense centers of action aid in intensifying the southwesterlies whirling around the semipermanent climatological Highs, such as the Azores High. The end result is the maintenance of the currents.

The Kuroshio Current, like the Gulf Stream, is fed by a westward-moving North Equatorial Current. This current divides east of the Philippines; the northern branch becomes the Kuroshio. The northward movement of the Kuroshio is only partly under the influence of the ever-persistent subtropical High. I say partly, because the Kuroshio is also a density distribution type current. After washing the west coast of Japan, the Kuroshio extends eastward and branches near 160°E. The southern branch, the North Pacific Current, turns back toward the west in the longitude of the Hawaiian Islands. The northern branch, however, eventually becomes the Aleutian Current. Near the mouth of the Columbia River, part of the Aleutian Current turns north and, as the Alaska Current, feeds into and warms the coastlands bordering on the Gulf of Alaska. The State of Alaska blocks the Alaska

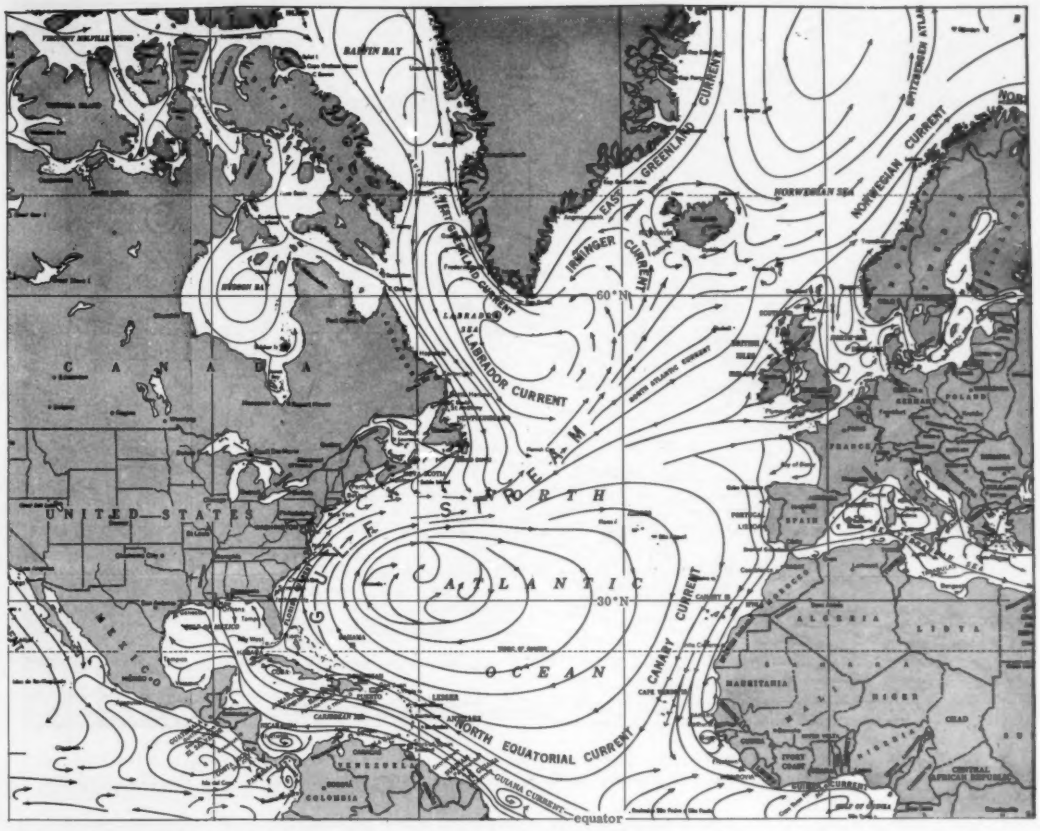

Figure 18.--General circulation of North Atlantic surface currents, July, August, and September. Defense Mapping Agency Pilot Chart.

Current at 60°N, preventing the polar regions of the North Pacific Ocean from sharing the blessed climate of Scandinavia. Part of the water of the Alaska Current passes between the Aleutian Islands into the Bering Sea. Easterly winds north of the Aleutian Low play a part in this westward transport, as does the momentum of the blocked current. Bering Sea water emerges southward on the east coast of Asia, as the Oyashio Current, discussed later in this article. That portion of the Alaska Current not entering the Bering Sea region rejoins the Aleutian Current.

The Kuroshio is not as mighty as the Gulf Stream, for two good reasons. First, there is no geographic feature in the Pacific with the current-deflecting potential of northeastern Brazil; and, second, the trade winds in the North Pacific Ocean are weaker than those in the North Atlantic, because they are not as close to their source, the subtropical High, when they reach the Asiatic land mass.

The Kuroshio Current is king, however, when it comes to breeding cyclones. Its distance from the stable subtropical High enables more storms to form and develop in the Kuroshio than any other place in the Northern Hemisphere. Tropical storms also follow the warm Kuroshio. Consequently, there is no marked dry season in Japan.

When there is a warm current in one part of the ocean, there must be a cold one in another region, so that the northward transport of heat can be in relative equilibrium with the southward transport. Two of the most notable cold currents of the western oceans are the Labrador of the North Atlantic and the Oyashio of the North Pacific.

The Labrador Current transports cold water of low salt content southward from Baffin Bay, through the Davis Strait, and then southeastward past Labrador and Newfoundland to the Grand Banks. The East Greenland Current, the main discharge of the Arctic Ocean, flows through the Denmark Strait, moves around Kap Farvel toward the Davis Strait. Here it reverses its direction, becomes the West Greenland Current, and reinforces the Labrador Current. It is interesting to note that the cold East Greenland Current is joined by most of the Irminger Current--one of the terminal branches of the warm North Atlantic Current. Aided by the easterlies on the north side of the Icelandic Low, this portion of the North Atlantic Current flows westward as the Irminger Current, off the southwest coast of Iceland.

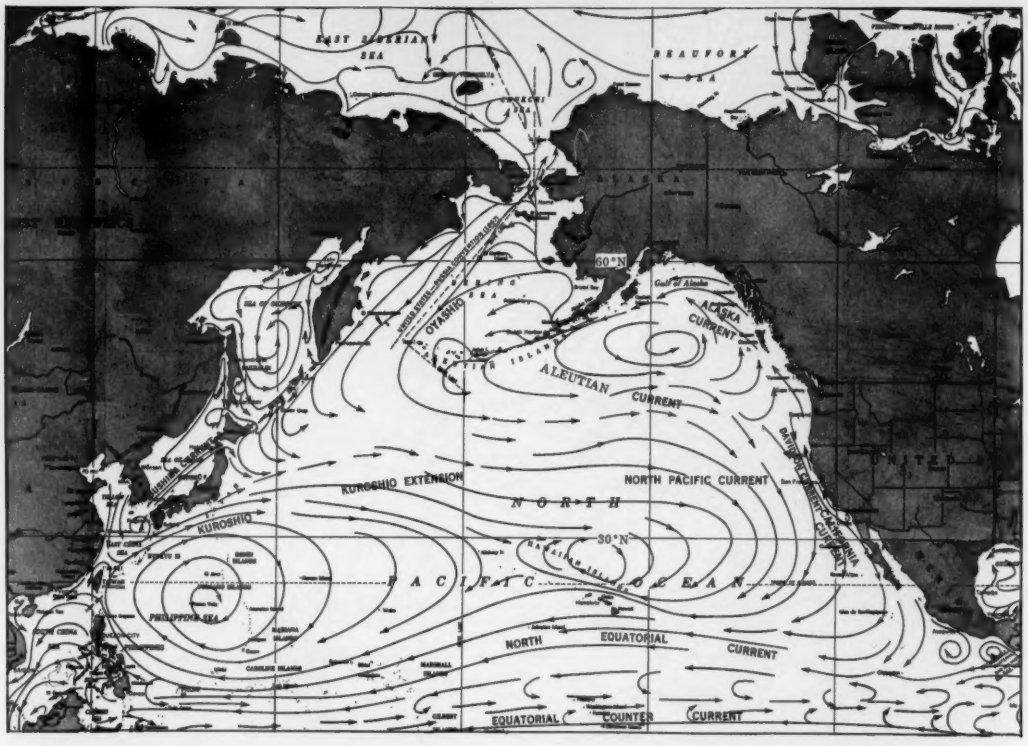

Figure 19.--General circulation of North Pacific surface currents, January, February, and March. Defense Mapping Agency Pilot Chart.

East of the Grand Banks, the waters of the Gulf Stream and the Labrador Current meet, and the two flow eastward, separated by the "cold wall," a steep seawater temperature gradient. A weak finger of the Labrador Current winds down the New England coast, however, reaching as far south as the Virginia capes.

The cold Labrador Current is the major cause of cool Newfoundland and Labrador summers. In an average year, the mercury never reaches 80°F (27°C) on the Labrador coast. Frost is experienced in all months of the year except July.

At St. John's, Newfoundland, the average July temperature is 59°F (15°C). Brest, France, at about the same latitude and also a coastal station, warms up to 65°F (18°C) in July. This substantial temperature difference is attributed to the cooling influence of the Labrador Current on St. John's, and the warmth of the Gulf Stream system on Brest. Another example of the influence of these two currents is the very large (40°F in February) north-south mean air temperature gradient between Florida and Nova Scotia--a distance of 2,000 mi.

During the spring and summer months, warm, humid air pumped northward from lower latitudes cools rapidly upon reaching the Labrador Current. Fog, one of the mariner's greatest enemies, is the result, especially southeast of Newfoundland over the Grand Banks. Icebergs, another major navigational hazard, are carried by the Labrador Current into the region at this time of the year. The West Greenland Current, flowing northward into the southern Davis Strait, aids in breaking up the edges of the icecap in that area, and the Labrador Current carries the splintered ice southward. Thus, the Labrador Current is the creator of two very real dangers for the mariner. Many ships, including the ill-fated TITANIC, have suffered tragic losses in these perilous waters.

The Oyashio Current of the North Pacific flows from the Bering Sea, a cold water reservoir of the Arctic Ocean, southwestward along the coast of Kamchatka, past the Kuril Islands. It then continues close to the northeast coast of Japan, reaching nearly 35°N. The Oyashio then turns toward the east, mixes rapidly with the northern branch of the Kuroshio extension, and eventually becomes the Aleutian Current.

The Pacific coast of Hokkaido (Japan), like the Maritime Provinces of Canada, may be shrouded by dense sea fogs, especially during the warmer months of the year. This results in much lower temperatures on the east coast of Hokkaido than on the west coast. Kushiro, an eastern Hokkaido city, has a mean August temperature of 64°F. Sapporo, on the west coast, records 5° higher. Unlike the east coast of North America, Asian coastal fogs are quite frequent in low latitudes during spring. The reason for this is

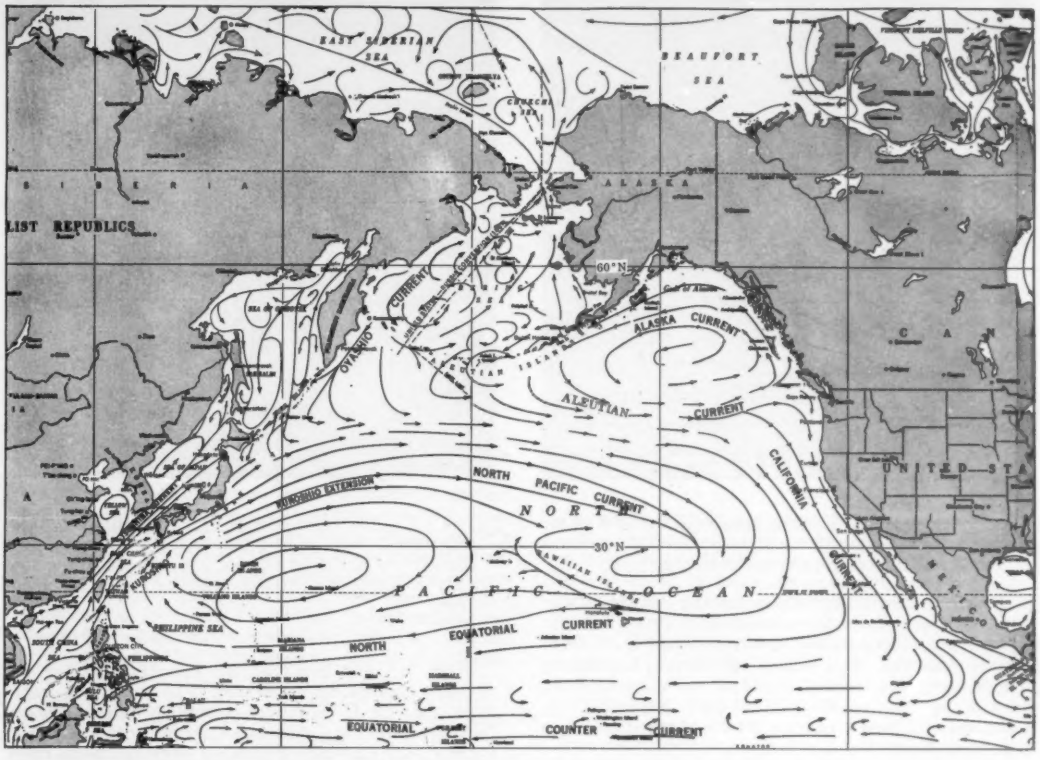

Figure 20.--General circulation of North Pacific surface currents, July, August, and September. Defense Mapping Agency Pilot Chart.

that some cold water from the Oyashio is able to buck the Tsushima Current (partially fed by the Kuroshio) of the East China Sea and the Sea of Japan. The residual Oyashio water then manages to pass through the Formosa Strait, to the vicinity of Hong Kong.

The Canary Current is the southward continuation of the North Atlantic Current, after it divides on the eastern side of the Atlantic Ocean. At division, the current is no colder than the northern branch which warms northwestern Europe. The Canary Current, however, takes on cold current characteristics as it flows southward past Spain and North Africa. It makes a westward swing at about 15°N and joins the North Equatorial Current, which, as stated before, feeds into the Gulf Stream system. The clockwise journey of the major currents surrounding the Azores High is now complete.

Northerly winds blowing over the Canary Current and parallel to the coastline, particularly during the warmer part of the year when land-sea temperature differences are at a maximum, produce an upwelling of cold subsurface water extending to a depth of 100 fathoms in extreme cases. This results in a strong seawater temperature contrast along the immediate coast. At Essaouira, Morocco (32°N), sea-surface temperatures of 60°F (16°C) have been observed at times, when 20 mi out from the coast the temperature at the surface was 70°F. In summer's warmest month, the average air temperature at Essaouira fails to climb to 70°F (20°C). Across the Atlantic, at Savannah, Ga. (32°N), the temperature of the warmest summer month (81°F) is 13° higher than at Essaouira. The mean July temperature along most of the Atlantic coast along the western fringe of the Sahara Desert is 20° lower than the interior, due to a vigorous sea breeze off the upwelled water. The nighttime temperature cannot fall too much lower than that of the upwelled water because of the frequent onshore breezes and high humidities described below. An added note about upwelled water--it is rich in plant nutrients, so that regions of upwelling are generally also areas of rich fishing.

The cool water temperatures off the coasts washed by the Canary Current are associated with fogs (fig. 21) or low stratus clouds, stable conditions and little precipitation. The aridity is caused principally, however, by the strong upper level subsidence (descent, warming, and drying out of air) within the Azores High. Coastal stations from Cape Rhir, Morocco, to Tamzak, Mauritania, generally receive less than 10 in of rainfall a year. Droughts are not felt along the coastline, however, because of the high humidities, fogs, and heavy dews which form during most nights.

The California Current of the North Pacific is very

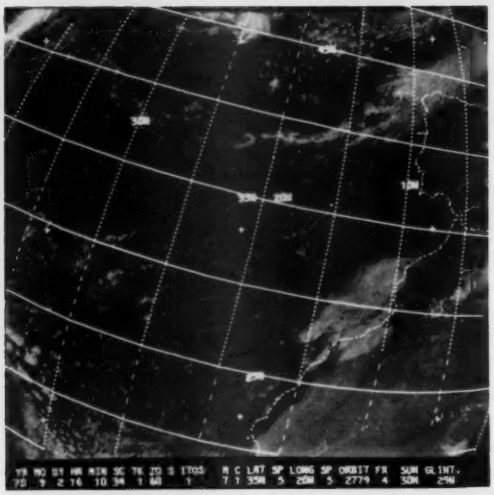

Figure 21.--Fog and stratus, caused by the cold water due to upwelling and the Canary Current, outlines the Moroccan coast in this satellite picture.

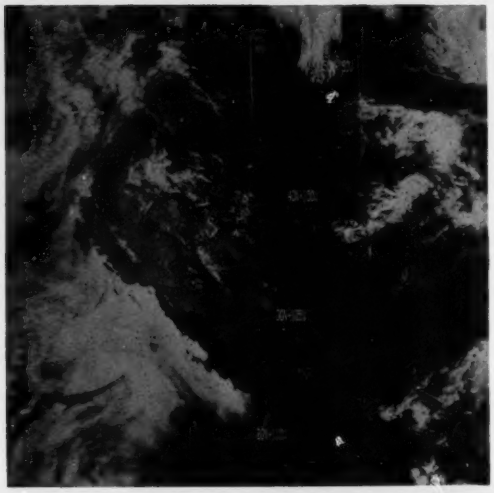

Figure 22.--The west coasts of California and Baja California, with colder water temperatures, are virtually mapped by fog and low stratus, while the Gulf of California, with its warmer water, is cloud free.

similar to the Canary. Branching off from the Aleutian Current, it flows southward along the west coast of the United States from Washington to northern Baja California. As a whole, the current represents a wide body of water that moves slowly southeastward, paralleling the coast. Off Central America, the California Current turns toward the west and becomes the North Equatorial Current.

The northward displacement of the Pacific subtropical High and the resulting fresh winds and cold upwelling cause a very small temperature range throughout the year in northern California, north of San Francisco. As an example, the same extreme maximum temperature of 85°F has been recorded at Eureka in both summer and winter months. When the Pacific High reaches its maximum northward displacement during July and August, upwelling from the California Current is strongest along this coast. Table 1 indicates this phenomenon, showing only one extreme air temperature for the year being recorded during a 30-yr period during the months of July and August. Note that extreme highs for the year have been reported in the winter months of December and February. From the general area of San Francisco southward to Baja California, insolation is the victor and summer is the warmest of the seasons. At Eureka, Calif. (40°N), the average July temperature is 56°F (13°C), while New York City (41°N), on the East Coast, averages 74°F (23°C). In more southerly latitudes, differences are not so large. San Diego (33°N) averages 67°F (19°C), while Savannah (32°N) has 80°F (27°C). Shanghai (31°N), on the western side of the North Pacific, averages 81°F (27°C) in July.

Rain is rare south of San Francisco during the summer months, but increases to a wintertime maximum after the Pacific High retreats to more southerly latitudes, and the California Current weakens. Then the Davidson Current appears--a warm countercurrent running north along the West Coast of the United States from California to the Washington coast.

As in west Africa, fogs straddle the Pacific coast, but the Gulf of California is virtually fogless, because of its much higher water temperatures (fig. 22). The mean July water temperature at Ensenada, Mexico (32°N), on the Pacific Ocean, is 69°F (21°C), while at Puerto Penasco, Mexico (31°N), on the Gulf of California, it is 85°F (29°C). Fog produced by cold currents rarely extends more than 50 mi inland anywhere in the world. For example, San Francisco has only 305 hr of sunshine during July, while Sacremento, 70 mi from the sea, has 426 hr.

East-to-west and west-to-east currents are also present over the equatorial regions of the North Atlantic and North Pacific Oceans. Paralleling the Equator, they do not play the role in heat transport that meridional currents do. The fundamental cyclic role of the trade-wind-driven, westward-flowing North Atlantic and North Pacific Equatorial Currents have already been discussed, but west-to-east currents have not been presented as yet. Let us look at the North Atlantic Equatorial Countercurrent and its unique branch, the Guinea Current, before reviewing its North Pacific counterpart.

Table 1.--Distribution by month of extreme high air temperatures recorded at Eureka, Calif., 1943-72

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	1		2	3	2		1	8	9	2	2

The North Atlantic Equatorial Countercurrent flows eastward between the North Atlantic and South Atlantic Equatorial Currents. It eventually becomes the Guinea Current, which then continues eastward along the south coast of northwest Africa into the Gulf of Guinea, reaching the coast at the Gambia River in summer and Sierra Leone during winter. The influence of the warm, humid air overlying the Guinea Current is not usually felt south of Cape Lopez. Libreville, 85 mi north of Cape Lopez, measures almost 100 in of rainfall a year. Eight degrees farther south at Banana, influenced by a cold Southern Hemisphere current, only 28 in of rain fall. Sixty inches fall at the latitude of Banana over interior stations. The paths of all major currents vary somewhat, however, and heavy rains have been known to fall along the coast at and south of Banana.

There is a narrow coastal strip along the Gulf of Guinea, between Cape Three Points and Nigeria, where an average of 30 in of rainfall is recorded each year, compared with amounts exceeding 80 in on either side of the strip. The prevailing winds are the same over both the wet and dry areas, but along the dry area they are parallel to the coast, resulting in some decrease in precipitation. The major decrease, though, results from upwelling (mainly from July through September) caused by the pull of surface coastal waters away from the immediate coast by the Guinea Current. Table 2 lists rainfall by month for Accra, Ghana and Douala, Cameroon. Both coastal stations are at almost the same latitude, and both are affected by the Guinea Current. At Accra, in the dry coastal strip, the shape of the coastline only serves to keep the Guinea Current far offshore, while at Douala the shape of the coast traps the warm Guinea Current, resulting in five times as much rainfall. Both stations should have their greatest amount of annual rainfall in the summer months and a minimum during the winter, because of the fluctuation (northward in summer, southward in winter) of the equatorial trough. This reasoning holds true for Douala, but at Accra a distinct rainfall minimum is present because of the heightened upwelling.

Table 2.--Average monthly rainfall, in inches, for Accra, Ghana and Douala, Cameroon. Note the predictably low rainfall at both locations during winter months, and the distinct July-September minimum rainfall at Accra, brought about by upwelling

ACCRA 5.5°N (average 31 in per yr)		DOUALA 4°N (average 159 in per yr)	
January	0.63	January	2.09
February	1.46	February	3.66
March	2.87	March	8.07
April	3.22	April	9.25
May	5.71	May	12.76
June	7.60	June	19.88
July	1.93	July	28.82
August	0.63	August	27.21
September	1.58	September	22.60
October	3.15	October	16.18
November	1.50	November	6.06
December	0.71	December	2.36

The North Pacific Equatorial Countercurrent is one of the swiftest of ocean currents; it flows eastward across the Pacific between 3° and 10°N. Along the Pacific coast of South America between the Equator and Panama, annual rainfall totals exceed all other South American locations. One primary reason for this is the ever-present equatorial trough; but light southwesterly winds blowing over the hot equatorial countercurrent onto mountain slopes are also a major contributor to very heavy rainfall.

This concludes my discussion of the major ocean currents of the North Atlantic and North Pacific Oceans. The second installment of "Ocean Currents and Their Relationship to Coastal Climate" will discuss and compare ocean currents of the South Atlantic and South Pacific Oceans. A third and final article will concentrate on Indian Ocean and Antarctic currents.

WE OF NOAA ARE MAKING USE OF THIS SMALL AMOUNT OF SPACE TO EXTEND OUR THANKS TO ALL THE SHIPS' OFFICERS WHO ROUTINELY TAKE SHIPBOARD WEATHER OBSERVATIONS. TO US, THESE EXCELLENT OBSERVATIONS ARE PRICELESS. WE CERTAINLY DO APPRECIATE RECEIVING THEM ON A REGULAR BASIS.

Hints to the Observer

WIND DIRECTION

Robert G. Quayle
Environmental Data Service, NOAA
Asheville, N. C.

The 36-point wind direction system for reporting meteorological observations has been in general use by mariners since 1949. In theory, this system presents the wind direction to the nearest 10 degrees of the compass. Often, however, because the 16 principal points of the compass are painted so boldly on the compass rose, the observer tends to be drawn to these points when taking his wind observations.

A good way to avoid this bias when estimating wind direction from the sea is:

1) sense the approximate wind direction and determine which waves are being driven by the local wind.
2) using a pelorus (preferably attached to a gyro repeater or magnetic compass) sight along the crests of the sea waves. Be careful not to use the swell waves (i.e., waves that have traveled beyond their source region).
3) add or subtract 90 degrees as appropriate to determine the direction from which the wind is blowing.
4) round the result to the nearest 10 degrees.

The above method is not to be interpreted as a substitute for those methods described in the observing handbooks, but rather as a supplement to them when measuring instruments are not available.

Figure 23 shows a summary of cool-season wind direction observations taken by an offshore station. Though the original observations were supposed to have been taken to 36 points, it is clear that they are very strongly biased to the four cardinal and four intercardinal points and, to a lesser extent, to the eight intermediate points.

As a final note, be careful not to be misled by those big fancy painted black arrows at the cardinal points of your compass. Look at the direction scale in degrees and proceed accordingly.

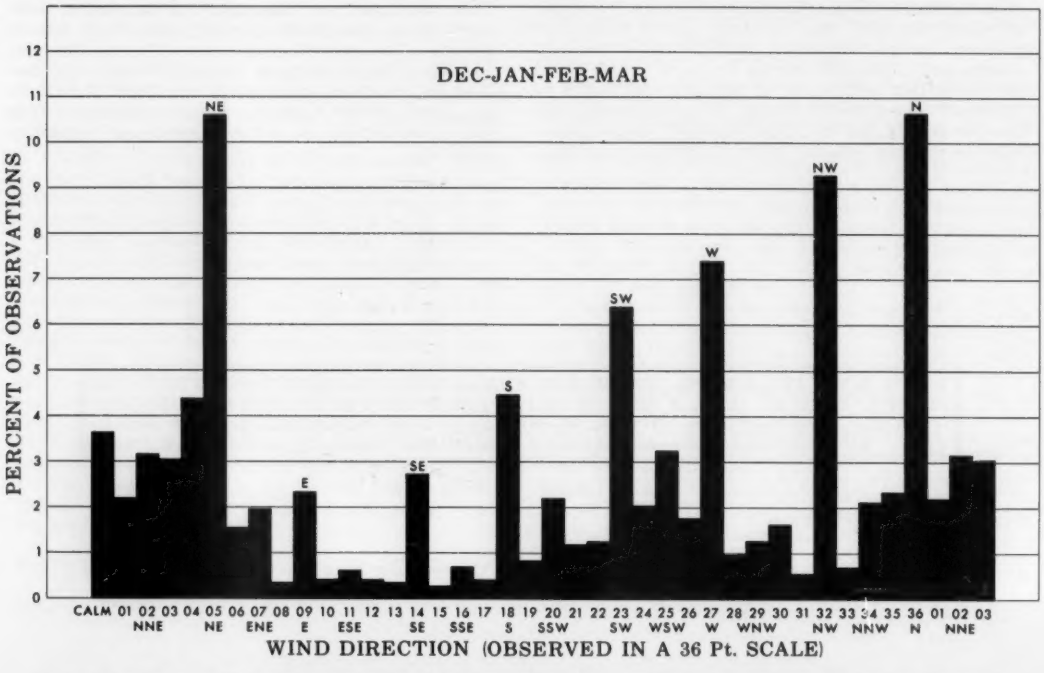

Figure 23.--Percent frequency distribution of wind direction showing bias to the cardinal and intercardinal points.

Tips to the Radio Officer

Warren D. Hight
National Weather Service, NOAA
Silver Spring, Md.

CHANGE IN PUBLICATION WEATHER SERVICE FOR MERCHANT SHIPPING

Pages effected: 13, 15, 21, and 24. On November 1, 1973, radio stations operated by RCA on the Atlantic and Gulf coasts will make the following broadcast changes.

Page 13--Chatham, Mass. (WCC), will discontinue all coastal forecasts and substitute the forecast for West Central North Atlantic waters (32°N-41°N, west of 65°) and New York Harbor.

Page 15--Tuckerton, N.J. (WSC), will discontinue all scheduled broadcasts, but will continue to broadcast warnings on receipt.

Page 21--Lantana, Fla. (WOE), will discontinue all forecasts for coastal waters.

Page 24--Port Arthur, Tex. (WPA), will discontinue the 1748 GMT broadcast, but will continue to broadcast warnings on receipt.

Page 63--Guam, Mariana Islands (NPN): Revise details as follows:

Area affected:

(a) Tropical waters of the Northern and Southern Hemispheres between 62°E and 180°.
(b) North Pacific and northern Indian Ocean from the Equator to mainland of Asia, between 62°E and 160°E.
(c) North Pacific from the Equator to 25°N between 130°E and 180°.

Call Sign	Time of Broadcast	Frequencies (kHz)	Class of Emission
NPN	0400, 1300, 1700, 2300	434	A_1
		4955	
		8150	
		13380	
		17530	
		21760	

Time of Broadcast	Type of Message		Contents of Message
0400, 1300, 1700, 2300	Warnings	Part 1:	Gale/Storm/Typhoon/Tropical Cyclone Warnings for the affected tropical and extratropical warning areas (a) and (b). Tropical warnings are issued every 6 hr in the Northern Pacific and at least every 12 hr in the Indian Ocean and Southern Pacific. Extratropical warnings are issued every 12 hr and updated as necessary.
	Forecast	Part 2:	24-hr forecast for area (c). This forecast includes a synopsis. The forecast is issued every 12 hr and is updated as necessary.

NOTE: The broadcast is compiled by U.S. Navy Fleet Weather Central, Guam.

WEATHER BROADCASTS VIA RADIOTELEPRINTER

We recently learned that Radio Station WLO, Mobile, Ala., broadcasts marine forecasts by radioteleprinter (F_1) at 0120, 1320, and 1720 on the frequency 8714 kHz. The forecast areas include offshore waters of the Gulf of Mexico, Western Caribbean Sea, and the Southwest North Atlantic, 20°N to 32°N and west of 65°W and Gulf of Mexico coastal waters, including the Florida Straits. Transmission speed is 66 words per min.

CHANGES IN PUBLICATION U. S. AND FOREIGN COASTAL RADIO STATIONS ACCEPTING SHIPS' WEATHER OBSERVATION MESSAGES (1973 Edition)

Page 6--Station NMF, Boston, Mass.: Change frequency from 8728 kHz to 8727 kHz.

Page 8--Delete entry for "4YV Ocean Weather Station V," etc.

Pages 8 & 20--Station NMO, Honolulu, Hawaii: Change frequency from 12743 kHz to 12786 kHz.

Page 8--Station NMC, San Francisco: Change frequency from 8465 kHz to 8574 kHz.

CORRESPONDENCE FROM RADIO OFFICERS

P. A. Cross, Radio Officer on MV DART AMERICA (GOOB), provided information on changes in working frequencies of Portishead Radio. We are checking with officials in the United Kingdom before publishing the new frequencies.

Ken Edwards, Chief Electronics Technician on NOAA Ship RESEARCHER, monitored the radiofacsimile transmissions from Radio NMF, Boston, and submitted cooies along with notes on time of broadcast, frequency, and position of the vessel.

We wish to thank both of these men for providing this information. We would also like to encourage others to send in information or comments on weather broadcasts they believe should be used to improve or correct our publication.

Hurricane Alley

Richard M. DeAngelis
Environmental Data Service, NOAA
Washington, D.C.

NEW PUBLICATION

One of the most complete climatic studies of tropical cyclones around the world will soon be available. It is called the Mariners Worldwide Climatic Guide to Tropical Storms at Sea, and is a U.S. Naval Weather Service Command publication, prepared by NOAA's National Climatic Center. This is a special edition based on information extracted from data being compiled for updating the U. S. Naval Weather Service Command's series of Marine Climatic Atlases of the World.

The guide provides information on where and when tropical cyclones occur, their frequency, and general tracks. It consists of 119 pages of illustrated text and 312 charts covering 6 ocean basins, monthly and annually. The tropical cyclones are summarized by four stages, including tropical storm, hurricane or typhoon, a combination of these, and some stages that are not so well documented in specific basins. The chart information is in the form of tropical cyclone roses, which indicate frequency, direction of movement, and speed. The breakdown is by 5° squares. The text includes discussions on ship handling and tips on avoiding storms, as well as information on specific basins and tropical cyclones in general.

While this guide is designed for the mariner, its information will be valuable to the industrial and scientific communities. Here is a valuable reference book that brings together for the first time tropical cyclone statistics on all ocean basins. Up until now, information on the southern hemisphere oceans was almost impossible to find in this country. Now, it's all in the guide.

The Mariners Worldwide Climatic Guide to Tropical Storms at Sea will be available through the National Climatic Center at Asheville, N.C. When it is ready, we will give you the details on the price and how to order, hopefully, in our next issue.

TROPICAL CYCLONE ACTIVITY

Unless there is a late spurt, tropical cyclone activity will be below normal this year in the seas of the Northern Hemisphere. So far, through September, 31 tropical cyclones (tropical storms and hurricanes or typhoons) have plagued these seas. The normal total is about 41 (table 3). Activity is below normal in every ocean basin. The biggest deficit is in the western North Pacific, where the number of storms is four below average. The season in this ocean got off to a late start (July), and only two storms formed in September (see page 404 of this issue).

NORTH INDIAN OCEAN

In the Indian Ocean, just one tropical cyclone has occurred through September (fig. 24). Even though this is the least active ocean basin, usually about three have formed by this time. Spring and fall are the two most active seasons in the North Indian Ocean. The last time that a tropical storm or hurricane didn't form before October in the Bay of Bengal was 1949.

On the 26th of May, a tropical depression was sighted in the Arabian Sea near 13°N, 60°E. Storms that form in this sea in May are inclined to move west-northwestward to the coasts of Aden, Muscat, and Oman. The depression reached tropical storm strength the following day (fig. 25). On the 28th, she became the tenth May storm to affect the Saudi Arabian Peninsula since 1891. Maximum winds were estimated at about 35 kt.

Table 3.-- Northern Hemisphere tropical cyclones

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
Average	0.5	0.3	0.5	0.8	3.1	3.8	8.3	12.2	11.8	8.6	4.9	2.1	56.9
1973	0	0	0	0	1	3	12	8	7				

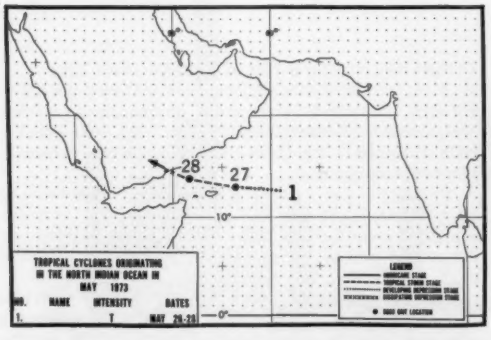

Figure 24.--Track of the Arabian Sea tropical cyclone of May 1973.

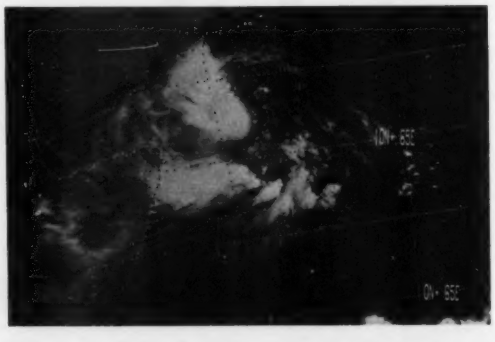

Figure 25.--The tropical storm lies embedded in the cloud mass north of 10°N at 0435 on May 27.

TROPICAL CYCLONE CLASSIFICATION

If you sail the North Indian Ocean, you know that a different system for classifying tropical cyclones is used. The term "tropical depression" is similar to other areas, and refers to a tropical cyclone with winds up to 33 kt. The next stage used by the Indian Meteorological Department is that of "moderate tropical storm," with winds ranging from 34 to 47 kt. Tropical cyclones with winds of 48 kt or more are labeled "severe tropical storms." While the term "hurricane" is not used as a separate category, they will often refer to a "severe storm with a core of hurricane winds" when winds reach hurricane force.

On the Editor's Desk

USE OF SILICONE GREASE AND DUST SHIELDS IMPROVES RADIO COMMUNICATIONS AT SEA

The National Oceanic and Atmospheric Administration has found the solution to a problem which has hampered radio communications at sea during stormy weather since ships first began using wireless.

During heavy weather of long duration, salt spray and water often short-circuit the insulators of radio antennas to such a degree that ships cannot communicate with other ships or with stations ashore, creating an especially hazardous condition for vessels requiring aid.

The radio antennas used for transmitting and receiving messages by radio telephone and telegraph are isolated from the ship's steel structure by porcelain insulators located near the deck at the base of the antennas. As long as these insulators are clean and dry and have a high polish, they prevent the electrical current in the antennas from short-circuiting to the ship's steel hull. But when these insulators become covered with salt crystals from ocean spray and rain water from squalls, the electrical current is diverted to the steel hull. The antennas' radiated power is then diminished and, during prolonged storms, often terminated entirely, making radio transmission impossible.

This problem has now been solved by coating the porcelain insulators with a silicone grease, to which water will not adhere. To protect the silicone grease from other contaminants, such as dust and particles from burned fuel oil, the grease is sheltered with a fiberglass shield, shaped like an inverted funnel.

Two years of testing by three vessels of the NOAA Fleet--the MT MITCHELL, RESEARCHER, and RAINIER--proved the success of the new method, enabling the ships to continue radiocommunications practically unhampered during stormy weather.

The first tests of the new method began aboard the MT MITCHELL in 1970. For the test, insulators in one of the ship's antennas was coated with the silicone grease, while the other was left uncoated, to act as a control. Subsequent testing aboard the MT MITCHELL, RESEARCHER, and RAINIER proved the method successful. The most recent test showed that during a voyage by the MT MITCHELL from the United States to France, the antenna continued to function well in severe weather, with rain squalls, high winds, and heavy spray. The RESEARCHER has been using the new method also, for over a year, with perfect results.

ACCORDING TO LLOYD'S REGISTER, SHIP LOSSES STILL AT HIGH LEVEL

A ship sank on an average of every day last year, as marine casualties amounted to a figure only marginally below that of the worst peacetime year for shipowners and their insurers.

According to Lloyd's register of shipping, 371 vessels of 949,336 tons gross were lost in 1972, only 6 vessels and 81,224 tons less than the record figure for any one year of 377 vessels of 1,030,560 tons in 1971.

At the same time, breakers' yards disposed of 917 ships of 4,994,148 tons, compared with 962 vessels of 4,266,007 tons in the previous year.

The greatest hazard at sea last year was fire. Altogether, losses amounted to 304,086 tons, the highest on record, and included the largest single loss, the 82,998-ton SEAWISE UNIVERSITY (ex-Cunarder QUEEN ELIZABETH). She was destroyed by fire at Hong Kong. Six tankers of over 12,000 tons were also burnt out, including the 33,403-ton Greek vessel PRINCESS IRENE, which was struck by lightning.

Foundering accounted for 218,819 tons--the second highest figure on record. The largest loss by this cause was the 21,469-ton Greek tanker TRADER, while, also in this category, the 148-ton wooden coaster RAPP 11, built in 1858, was the oldest casualty of the year.

Another record figure was set for collisions, with a total of 211,241 tons sunk. Again, oil tankers--the 63,988-ton South Korean SEA STAR and the 48,339-ton Liberian TEXANITA--were the largest casualties.

The number of vessels wrecked, at 230,233 tons, were only half those of the previous year. Another oil tanker, the 20,576-ton MARATHON, was the largest single loss.

Altogether, casualties amounted to 0.65 percent by vessel and 0.35 percent by tonnage of the world's fleet, which totaled 57,391 ships of 268,340,145 tons.

The total tonnage broken up during 1972--4,994,148 tons--was also at a new peak, and, in the light of today's freight rates, it seems unlikely that this figure will be bettered this year. War-built tonnage laid-up in the United States continued to provide the bulk of the scrappings.

The United States, in fact, sent 1,432,146 tons, or 9.5 percent of its fleet, to the breakers' yards. Other countries with large disposal figures were the United Kingdom (810,971 tons), Liberia (539,820 tons) and Panama (500,925 tons).

The largest vessel to be scrapped was the 24,682-ton tanker OLYMPIC LAUREL, and the oldest was the Italian motorship STADIUM, which was built in 1877.

GREAT LAKES PRECIPITATION ABOVE NORMAL SO FAR IN '73

Water levels for the Great Lakes, which have been marked by record highs this year on some lakes, are expected to remain well-above average through late fall, with Lake Erie and nearby Lake St. Clair continuing to set new monthly record highs.

The Lake Survey Center disclosed that the amount of rain and snow for the first 7 mo of this year totaled 19.12 in, about 8 percent above normal.

Below-normal precipitation prevailed during the first 2 mo of the year, being 19 and 24 percent, respectively, below the norm. From March through June, precipitation was above normal, 39 percent in March, 8 percent in April, 44 percent in May, and 20 percent in June. Incomplete results for July show that the Great Lakes basin received about 24 percent below normal rainfall for that month. Preliminary figures for August indicate above-normal rainfall for that month, with the Lake Superior basin receiving twice the normal rainfall during the first 2 wk, with 4 in recorded.

For individual lakes, the greatest deviation from average monthly precipitation rates occurred on Lakes Erie, Michigan, and Huron. In March, the Lake Erie basin, which includes Lake St. Clair, received 71 percent above normal precipitation. In May, Lake Michigan received 66 percent above normal and Lake Huron, 58 percent above the norm.

Average precipitation rates vary with each lake and month. The average annual precipitation for the entire basin is about 31 1/2 in, while that for Lake Ontario, to cite one example, is a little over 34 in.

Much of the precipitation this year fell early in the year, before or at the beginning of the growing season. Contributing to the increased runoff to the lakes was the nearly saturated condition of the basin.

Precipitation data are collected by the Lake Survey Center to aid in various ongoing studies and investigations of Great Lakes water levels. Extensive use is made of data furnished by NOAA National Weather Service stations. Special computations are made to refine raw data, and a complex formula is employed to measure precipitation over water, which is usually different from that over adjacent land areas.

The NOAA Lake Survey Center estimated that the above-normal precipitation of 1 1/3 in--normal 17.72 in--recorded for the Great Lakes basin during the first 7 mo of the year, brought with it billions of gallons of additional water.

An inch of rain doesn't seem like much, but when you start adding up what goes into it, you come up with some surprising data. To cite a few examples, an inch of rain falling in Chicago's 211.3 sq mi equals 3.86 billion gallons of water; Detroit, with its 142 sq mi, 2.4 billion gallons; and Cleveland, with 73.1 sq mi, 1.2 billion gallons. An inch of rain on 1 sq mi equals approximately 17.4 million gallons of water.

NEW BUOY WILL TEST ACCURACY OF ENVIRONMENTAL OCEAN BUOYS

The development of a buoy designed to monitor the accuracy of meteorological and oceanographic information transmitted by environmental ocean buoys was announced by NOAA.

The 64-ft-long spar-type buoy, known as the Measurement Comparison System, includes a 30-ft hull which provides a stable support base for a 34-ft mast (fig. 26) which rises above the water. The 10-3/4-in diameter spar assembly houses the battery supply, which powers the buoy for up to 2 days of continuous operation, as well as all signal-conditioning and radio electronics elements. The internal instrument packages include signal conditioning elements, compass, and vertical accelerometer.

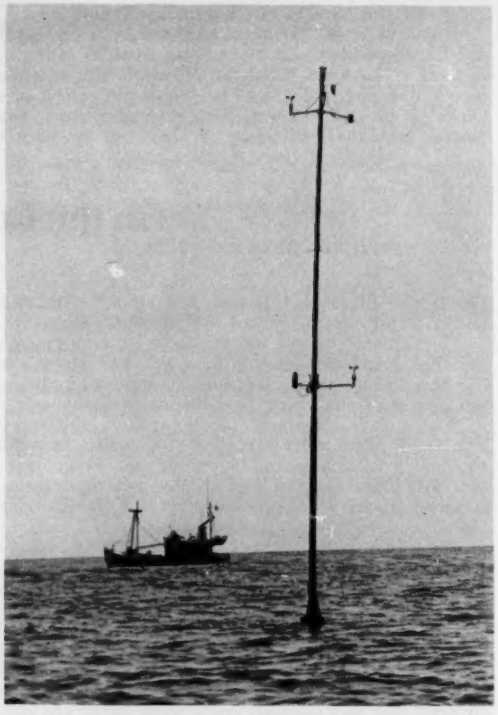

Figure 26.--Buoy developed for NOAA to monitor the accuracy of meteorological and oceanographic information transmitted by environmental buoys.

The buoy was constructed at the Lockheed Ocean Laboratory in San Diego, Calif., for the NOAA Data Buoy Office and has undergone successful tests in the Gulf of Mexico.

It is designed for use by support vessels which periodically service environmental buoys being developed by the NOAA Data Buoy Office and now being tested in the Gulf of Mexico, the North Atlantic, and the Gulf of Alaska.

When in use, the spar buoy will be tethered to the moored environmental buoy. It will begin relaying data through a very high frequency transmitter to a receiver and magnetic tape recorder aboard the supporting vessel.

After sufficient data are recorded, usually after a period of at least 24 hr, the spar buoy is recovered and transported to the next environmental buoy.

COAST GUARD ENDS 6-MONTH ICE PATROL--CUTTERS USED SECOND TIME IN 14 YR

More than 800 icebergs, about half of last year's

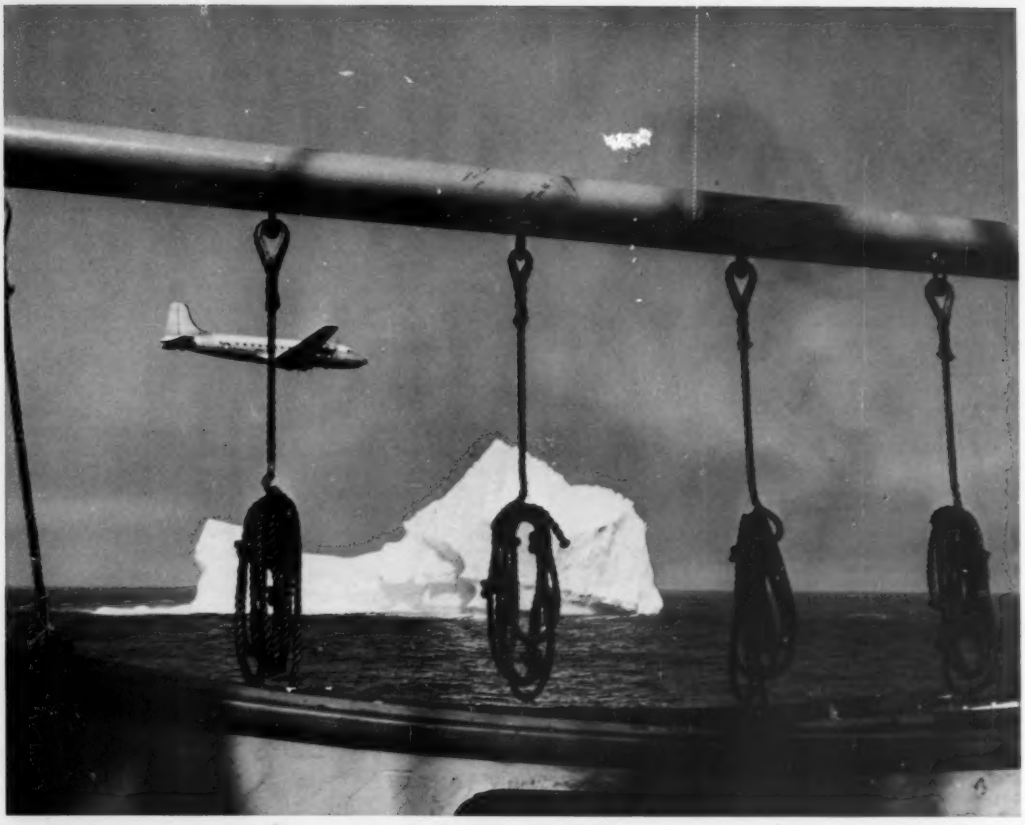

Figure 27.--Lifelines frame a twin-peaked iceberg in the North Atlantic shipping lanes. Normally, the Ice Patrol is carried out by Coast Guard planes off the Grand Banks off Newfoundland. Only when there is a heavy concentration of icebergs threatening shipping lanes are cutters called out for standby to warn ships.

record number, menaced North Atlantic shipping from January to July. However, this year they reached the trade routes earlier than at any time over the past decade, and, because they penetrated well into the shipping lanes, required the use of Coast Guard cutters for the second time in 14 yr to augment aircraft monitoring them.

On a preseason flight in January of this year, more than 60 bergs were found at the 50th parallel. Bergs become a hazard to shipping as they drift below the 48th parallel off Newfoundland's Grand Banks region.

Because of the early concentration of bergs that far south at that time of the year, the Coast Guard began tracking them and broadcasting their position January 24. In March, when icebergs were found at a latitude 900 mi east of Boston, the Coast Guard assigned cutters to the program. This was the second consecutive year that ships were used in addition to regular ice patrol flights (fig. 27).

The vessels used were the 210-ft medium endurance class cutters--DECISIVE, New Castle, N. H., ALERT, Cape May, N. J., VIGOROUS, New London, Conn., STEADFAST, St. Petersburg, Fla., DEPENDABLE, Panama City, Fla.--and the 255-ft high endurance class cutter MENDOTA, New Bedford, Mass.

In April, however, the wind began blowing southeasterly off Newfoundland and pushed the bergs into eastbound ocean currents before they could reach the sea lanes, thus explaining the smaller berg count than last year.

As the ice moves to the south or east, it encounters warmer waters and begins to melt rapidly. The widest dispersion below the 48th was found to be in early May, when icebergs were sighted in some 190,000 sq mi of ocean. For the 1973 season, the southernmost icebergs were found on a line with New York City, and the easternmost, some 600 mi southeast of St. John's, Newfoundland. The final Ice Patrol broadcast of the season was made on July 31.

An average of less than 300 bergs annually drop below the 48th parallel. For the past two seasons, the iceberg migration into the Grand Banks area has been well-above average. An estimated 10,000 bergs break off the West Greenland glaciers each year. How many of them reach North Atlantic waters after a

nearly 24-mo, 1,800-mi journey depends on the whims of the weather and oceanographic variables. These conditions make long-range predictions impractical.

The 4 yr preceeding 1972 were below-normal ice seasons, and statistics over the last 25 yr show an apparent decline in the number of icebergs reaching the 48th parallel.

International Ice Patrol operations began 1 yr after the tragic sinking of the British luxury liner TITANIC in April 1912, when it struck an iceberg some 300 mi southwest of Newfoundland with the loss of more than 1,500 lives.

The Coast Guard carries out the yearly surveillance of icebergs. The cost of the operation is shared by 18 other maritime nations, proportionate to the amount of their shipping passing through the ice-endangered sea paths.

SEA-SURFACE TEMPERATURE DATA OBTAINED BY NOAA-2 AVAILABLE

Magnetic tapes of sea-surface temperature observations taken by the NOAA-2 polar-orbiting environmental satellite are now available from the Environmental Data Service's National Climatic Center. Each of the seven-track, 556 bytes per inch, binary mode tapes covers 1 month for the period December 1972 to March 1973. The tapes contain data on position, time, and temperature in degrees Kelvin, as well as reference information. Each tape has been checked for data content and tape quality by the National Environmental Satellite Service, which controls the satellite through its command and data acquisition stations at Wallops, Va., and Gilmore Creek, Alaska. NESS also processes the satellite data on its CDC 6600 computer in Suitland, Md., then forwards the tapes for archival to NCC.

In the future, NCC will receive one NESS archive tape each month of NOAA-2 sea-surface temperature data within 30 days of the month of data collection. Duplicate copies of these tapes are available from NCC at $60 per tape, or selected data can be extracted and furnished at cost. Estimates of these costs will be made on request.

NEW VOLCANIC ISLET EMERGES

The Japanese Maritime Safety Agency confirmed the birth of a new volcanic islet about 600 m southeast of Nishinoshima Island, in the Ogasawara Group, on September 14.

It was the first island created around the Japanese Archipelago since Myojinsho Islet emerged out of the sea about 60 km south of Aogashima Island in the Izu Islands in 1953.

The confirmation was made by scientists aboard a plane which flew over the erupting islet. The chief of seismological research of the Meteorological Institute said that the volcanic islet might disappear any time after a violent eruption or be swept by big waves.

As of the 14th, the new islet was circular, with a diameter of about 120 m, and the highest point was about 40 m. The crater in the center of the rocky islet was about 70 m in diameter. The crater was erupting every few seconds and shooting up black rocks and white smoke incessantly, according to the scientists. Rocks were being shot up to the height of about 300 m, at intervals of about 30 sec. The smoke reached an altitude of about 1,500 m.

There was a round belt of reddish brown water around the islet, stretching for about 100 m, and water outside it was yellowish, according to the report.

NOAA OCEANOGRAPHERS USE SATELLITE DATA TO STUDY WATER QUALITY CHANGES

Satellites and scientists are teaming up to learn more about water quality changes and waste disposal in coastal zones. Oceanographers with the Physical Oceanography Laboratory recently released an analysis of images taken by the NASA Earth Resources Technology Satellite that documents waste disposal in the New York-New Jersey coastal area. The images show evidence of at-sea disposal and dispersal rates of the wastes dumped.

The oceanographers are studying the coastal area as part of NOAA's 5-yr regional ecology investigation of the New York Bight--the 15,000 sq mi area of ocean waters and continental shelf that extends from Montauk Point, Long Island, to Cape May, New Jersey. The New York Bight Investigation is the first project undertaken by NOAA's Marine Eco-Systems Analysis (MESA) program. Principal aims of the MESA program are to make a broad analysis of baselines and changes in biological, chemical, geological, and physical aspects of coastal areas, and to develop a capability to predict the environmental consequences of proposed changes.

As part of the program to monitor water quality in the area, NOAA is planning to install a total of 56 current meters in the Bight region by the spring of 1974. Twenty-two of the meters were installed this summer to make measurements of water movement during a 45-day period in August and September. Data gathered from the current meters and water samples will supply "ground truth" information to provide a basis for identifying ocean features "seen" by the ERTS satellite as it passes over the area every 18 days at approximately 900 km (570 mi) above the earth.

The New York Bight region was chosen as the first MESA study area because it is one of the most heavily used coastal areas in the United States and its problems need urgent attention. At present, data collection efforts are concentrated in the apex of the Bight--the area out to approximately 56 km (35 mi) from the mouth of the Hudson River--where the largest problem and greatest changes occur.

Within the following 2 yr, it is planned to expand the MESA work area approximately 160 km (100 mi) seaward to the edge of the Continental Shelf. Scientists then can determine what happens to particulate and dissolved wastes once they leave the metropolitan complex--whether they go out to the open ocean or remain along the Continental Shelf.

To date, work in New York Bight indicates that images made by satellites, such as ERTS, taken in an area of complex oceanography and high population density, can effectively be used to survey water-quality changes and measure the effectiveness of waste-dumping procedures. It seems likely that satellites with sensors, optimized to view the ocean in visible and infrared wavelengths, will supply wide-area data and will make management of the coastal zone on a broad scale much more realistic.

The Multispectral Scanner System--one of two imaging sensors aboard the ERTS satellite--images

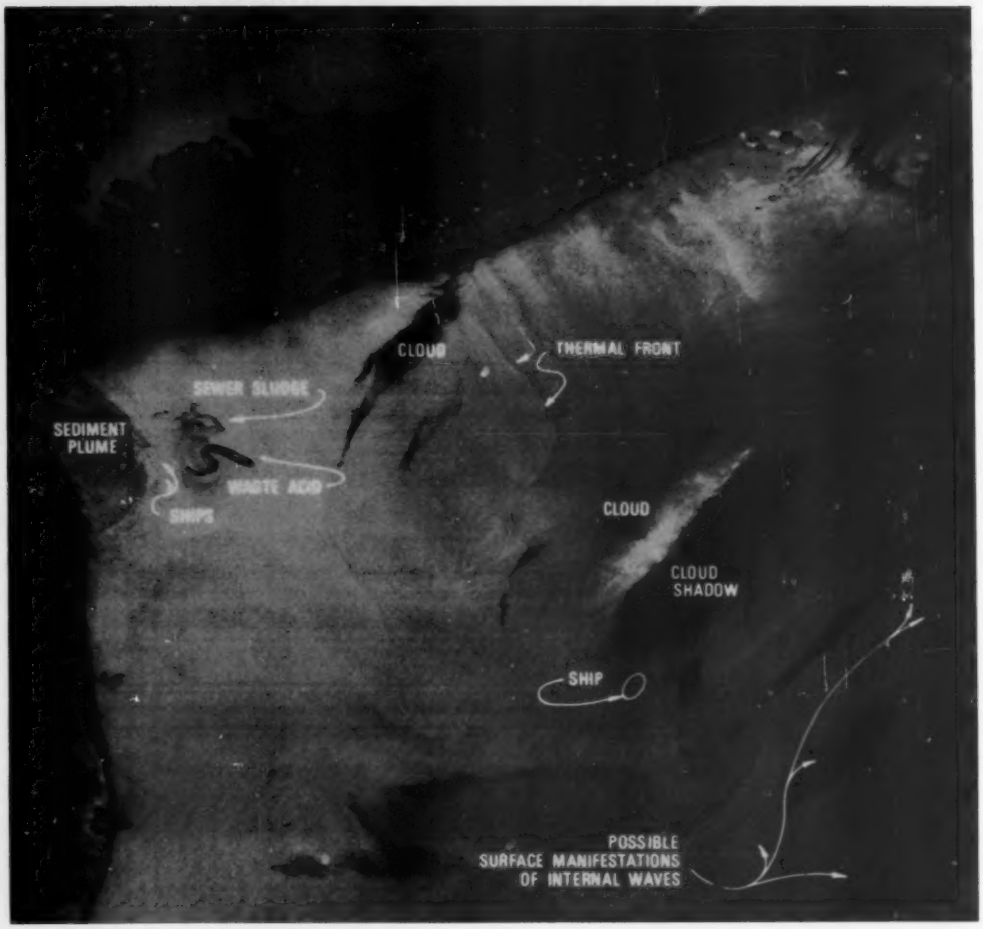

Figure 28.--This picture, transmitted from NASA's Earth Resources Technology Satellite, shows a number of interesting features in the New York Bight.

the ocean surface in four spectral bands simultaneously through the same optical system. Each band measures reflected light that penetrates to a different depth, thus giving a rough profile of the ocean. The depth profile information will greatly assist the scientists in studying movement and dispersal of particulate waste plumes, some of which have been seen to cover a wider area under water than at the surface.

The satellite images' (fig. 28) most prevalent oceanic feature in the Bight was the existence of visibly turbid surface water near the coast, produced by the action of waves and tides at the shore in maintaining suspended particulates and in the plume of New York Harbor effluent. Farther from shore, the settling of sediment and its mixing with Continental Shelf water decreased turbidity as suspended materials were dispersed. Surface traces of waste acid and sewer sludge disposals could clearly be seen in the satellite images in the area set aside for waste disposal, approximately 35 km (20 mi) southeast of the New York Harbor mouth. Since between five and six bargeloads of sewer sludge and an average of two bargeloads of waste acid are disposed of daily, sufficient material should remain in the area to be perpetually detectable by remote sensing. In fact, all ERTS images examined to date show traces of waste dumps.

RIVER AND HARBOR AID TO NAVIGATION SYSTEM

The Coast Guard is almost halfway through development of a RIHAN (RIver and Harbor Aid to Navigation) system that will allow navigators to more safely and accurately operate vessels in close-navigation situations common to rivers and harbors.

Currently, vessel captains have to rely on visual sighting of current aids to navigation in these areas. When the RIHAN system is perfected, ship navigators will have the accuracy of electronic navigation.

Two contracts have been awarded by the Coast Guard to assure further development of two types of electronic systems. Under phase two of a four-part RIHAN program, RCA Corporation, Van Nuys, Calif., will develop and test work-ups of their proposed microwave system. TRACOR Incorporated, Austin, Tex., will develop their low-frequency radio beacon system. Both systems operate in currently existing allocated radio bands. The microwave system works within the existing marine radio navigation frequencies and the low-frequency system operates within the marine radio beacon band.

The Coast Guard is also testing another electronic system already in existence to see if it would be an effective RIHAN system. Earlier this year, a contract was awarded to the International Navigation Company of Bedford, Mass., to determine whether the LORAN-C (LOng Range Aid to Navigation) system can be used for RIHANS.

Eventually, the RIHAN system will be incorporated into the Coast Guard's expanding Vessel Traffic System (VTS) for major commercial harbors. Part of VTS is a traffic separation scheme, and RIHAN would be the navigation system used by vessels while in a traffic separation scheme.

LETTERS TO THE EDITOR

ENCOUNTER WITH TYPHOON IRIS

Wolfgang Hastenrath, 1st Officer of the TAEPING, wrote the following description of that ship's encounter with typhoon Iris on August 14 and 15. He requested the actual track of typhoon Iris, which was mailed to him, using the positions from the Joint Typhoon Warning Center warnings.

"At 1652 GMT on August 13 (0052 on August 14, Hong Kong time), the German containership TAEPING left the harbor of Hong Kong, bound for Kobe, Japan, through the Formosa Strait.

"In the first weather report received, typhoon Iris was located near 24.2°N, 132.3°E, at 2100 August 13.

"The weather conditions were good through the Formosa Strait, with the wind from the southeast, shifting later from the east at Beaufort 2.

"On August 14 at 1500, the position of the TAEPING was 26°N, 122.9°E. During the following hours, the wind shifted to the northwest, with increasing speed--7 to 8 Beaufort--and the sea became rough. At 0000 August 15, Iris was at 25°N, 131°E, with a pressure of 975 mb, moving toward the east-northeast at 6 kt. The forecast was for Iris to be near 32°N, 129.2°E in 24 hr.

"About 0230, the wind shifted to the north-northwest at Beaufort 8. At 2300 on the 14th, the barometer read 997.5 mb and, at 0300 on the 15th, 991 mb. By 0700, the pressure had dropped to 985 mb.

"At 0130 on the 15th, ship speed was reduced to 16 kt; 20 min later, to 14.5 kt; and, by 0300, to 9.5 kt.

"A weather report located Iris near 28.4°N, 129°E at 0220, moving northwesterly to north-northwesterly at 12 kt. The next report positioned the typhoon near 28.5°N, 129°E, at 0300. In the opinion of the ship's officers, the storm was located more to the southwest than reported. Using tables and diagrams, the following data was determined.

"The wind speed in the eye of the typhoon was estimated to be 62 kt, with it increasing about 4 kt per hr while the ship was on a true course of 064°.

"Because of lack of information and only our ship's observations being available, Iris was estimated to be located near 27.9°N, 128.5°E, at 0300.

"At 0536, the course was altered to 126°, in order to keep clear of the typhoon, since, according to current observations by the ship, it seemed that the typhoon would move in a north-northwesterly direction.

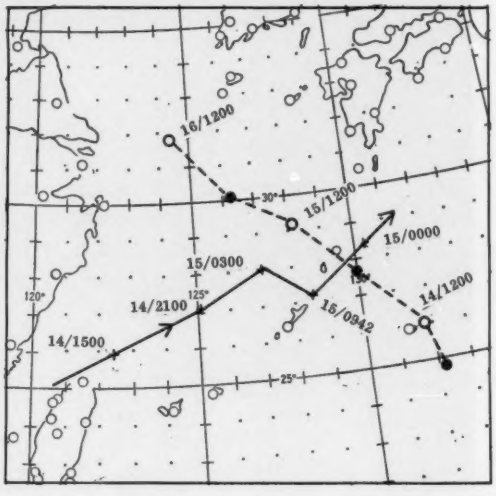

Figure 29.--The track of the German containership TAEPING during its encounter with typhoon Iris. (Ship's course, solid line; typhoon's track, broken line.)

"By 0942 on the 15th, the TAEPING had passed between Okinoyerabu Shima and Yoron Shima, and changed course to 055°. The wind now was from the southeast at Beaufort 7, and the pressure was increasing. The last report received on Iris placed her near 30.2°N, 126.6°E, moving northwest at 9 kt, at 2100 on the 15th.

"The following are observations as recorded by the TAEPING (the positions were interpolated from a chart attached to the letter):

Time (GMT)	Position	Wind (Beaufort)	Seas	Pressure (mb)
14/2100	27.1°N, 125.2°E	NW-W, 4	Moderate	1000
15/0220	28.0°N, 127.1°E	NE, 7	Very Rough	992
15/0300	28.2°N, 127.2°E	NNW, 8	Very Rough	991.2
15/0600	28.0°N, 127.5°E	NW-W, 9	Very Rough	986

Editor's Note: Figure 29 is a plot of the track of the TAEPING, with Iris' positions, as obtained from tropical cyclone warnings from the Joint Typhoon Warning Center, Guam.

Smooth Log, North Atlantic Weather

May and June 1973

The SMOOTH LOG (complete with cyclone tracks [figs. 32-35], climatological data from U. S. Ocean Station Vessels [tables 4-7, 9] , and gale tables 8 and 10), is a definitive report on average monthly weather systems, the primary storms which affected marine areas, and late-reported ship casualties for 2 mo. The ROUGH LOG is a preliminary account of the weather for 2 more recent months, prepared as soon as the necessary meteorological analyses and other data become available. For both the SMOOTH and ROUGH LOGS, storms are discussed during the month in which they first developed. Unless stated otherwise, all winds are sustained winds and not wind gusts.

SMOOTH LOG, MAY 1973--In general, the cyclones over the North Atlantic during this month were weak and diffuse, although near to slightly below normal in number. Only off the U. S. East Coast and over the Great Lakes did the storm tracks closely compare to the climatological tracks. The primary storm tracks during May, according to climatology, are over and north of the Great Lakes and up the U. S. East Coast, converging near Newfoundland. Out of this convergence, one primary track moves up the Davis Strait, while another branch is directed northeast, toward the Faeroe Islands. Further out to sea, two other more northerly tracks join the primary track, south of Greenland and south of Iceland. The busiest path this month was the one about 400 mi off the East Coast, which turned eastward, south of Newfoundland, and did not take a northerly component until the vicinity of 10° to 20°W. A second path was over Newfoundland to the Denmark Strait, then easterly, across Iceland.

The mean pressure pattern was near normal in configuration, with no outstanding differences in pressures. The Icelandic Low is not normally identifiable as a major closed circulation, as in the winter months, and was not there this month. The Azores-Bermuda High dominates from shore to shore, and to approximately 50°N. The central pressure was 1024 mb, or 2 mb higher than normal. Another closed HIGH is centered near the North Pole. This month it was centered further south, over northern Greenland, and 5 mb higher than normal at 1025 mb. A small 1019-mb High was located between Newfoundland and Kap Farvel. During this month, there were three ill-defined Low centers in a trough area that reached across Ireland, north-northeastward to a center near 80°N, 80°E. The lowest pressure of the three centers was 1012 mb. A 1010-mb Low was centered over Lake Michigan, in a tongue of low pressure out of the climatic Low over northern Mexico.

The major anomalies were positive and in the higher latitudes, a plus 8 over northern Greenland, and a plus 9 near 56°N, 50°W. A negative 3-mb departure was over Lake Michigan near the low-pressure center. A negative 3- to 4-mb anomaly trough paralleled the low-pressure trough along the northwestern European coast. The pressure over the Mediterranean Sea was 3- to 5-mb higher than normal.

Tropical cyclones are infrequent during May. In the past 42-yr history, only nine have occurred, two of which attained hurricane strength. None occurred this month, to make it nine in 43 yr.

This storm consolidated in the Texas-Oklahoma panhandle, and caused havoc in many places as it moved across the Great Lakes and out to sea by the 5th. It triggered violent thunderstorms across the Midwest and seven tornadoes in northern Oklahoma and southern Kansas. Two inch hail fell in central Illinois, to a depth of 1 ft in places. Three inches of rain fell in 45 min in northwestern Illinois to further aggravate the record flooding. The 999-mb LOW moved over Lake Michigan, at 1200 on the 2d. Gale-force winds were blowing across the lakes from the 1st through the 3d, accompanied by rain and snow. Seven ships reported high winds on Lake Superior. Late on the 1st, the BENJAMIN F. FAIRLESS was buffeted by 38-kt gales near the eastern end. On the 2d, the following ships reported the indicated winds and waves from one end of Lake Superior to the other: ARTHUR M. ANDERSON, 41 kt and 13 ft; ERNEST R. BREECH, 40 kt; PAUL H. CARNAHAN, 39 kt and 8 ft; EDMUND FITZGERALD, 47 kt and 10 ft; G. M. HUMPHREY, 42 kt and 8 ft; and the MIDDLETOWN, 48 kt and 11.5 ft. At 0000 on the 3d, the ARTHUR M. ANDERSON was hit by 42-kt winds and the seas as high as 20 ft, near the middle of the lake. A town in northern Michigan received 13 in of snow on the 2d and 3d. Rain and thundershowers continued as the storm moved across the eastern United States and Canada.

On the 5th the LOW crossed the Gulf of St. Lawrence, and by 1200 on the 6th was in the Labrador Sea. The LOW moved rapidly into the Denmark Strait, where it braked to a crawl on the 8th. Two stations on the east coast of Greenland reported 45-kt gales, and the CIROLANA, 200 mi southeast of Iceland, encountered 35-kt gales. The maximum wind plotted for Ocean Station Vessel "A" was 35-kt, on the 9th, on the back side of the LOW. At that time, she had 12-ft seas and 21-ft swells. By 1200 that day, the 990-mb center had moved east of Iceland to near 61°N, 8°W. The ATLANTIC CONVEYOR, near 57.5°N, 13.5°W, found winds of 60-kt. At this time, the LOW made an abrupt turn to the south, as a small wave moved over England. On the 11th, the LOW again turned northward, and late on the 11th, northwestward. On the 12th and 13th, it was stalled near 70°N, 2°E, and by the 14th, it had been absorbed by another system moving across the Norwegian Sea.

As the storm described above moved across Canada and into the Labrador Sea, a strong trough extended south off the U. S. East Coast. On the 1200 chart of

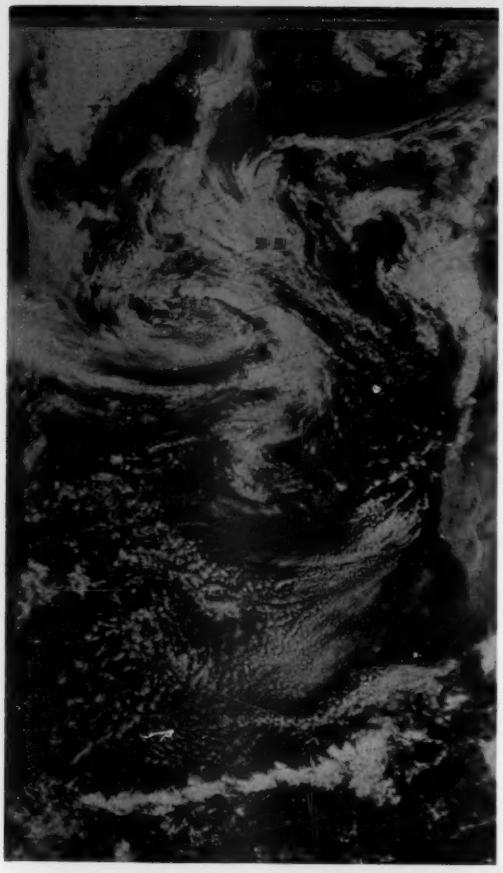

Figure 30. --The storm center is not well defined in this NOAA-2 satellite picture, at 1214 on the 18th. The LOW's center at 1200 on the 18th, according to ship reports was located near 46°N, 28°W.

the 6th, another 1010-mb LOW developed in the trough near 39°N, 63°W. As the other LOW moved northward, this new LOW moved eastward. Late on the 7th and early on the 8th, the HUDSON and the USCGC MORGENTHAU were bounced by 35- and 40-kt winds southwest of the center. By 1200 the LOW, near 42.5°N, 56°W, had a pressure of 1003 mb. On the 9th, the DOROGOBUSH found 35-kt winds near 41°N, 61°W.

By the 11th, the 998-mb LOW was headed northward off Newfoundland. The MORGENTHAU measured 36-kt winds at 42.9°N, 48.1°W, and the AMERICAN ACCORD, near 42°N, 53.7°W, contended with 35-kt gales and 14.5-ft seas. Ocean Station Vessel "D" also had 35-kt gales.

The LOW was again moving eastward and filling rapidly. On the 13th, it curved southeastward and, on the 15th, it was absorbed by the general circulation.

The center of this long-lived LOW, which formed on the 15th, over Cape Hatteras, stayed over water its entire life, except when it passed over Nova Scotia and Newfoundland. The storm moved northeastward up the East Coast. The EXPORT AIDE was hit by 35-kt gales off Cape Hatteras. On the 16th and 17th, the LOW passed Nova Scotia and Newfoundland. It now was better organized, and expanding its closed circulation. On the 18th (fig. 30), as it turned eastward, the LOW had a pressure of 990 mb. The USCGC DUANE and Ocean Station Vessel "D" were pounded by 40-kt shifting winds, as the still small but intense center moved north of them. Later in the day, the ADVISOR/9V22, near 45°N, 37°W, and the LUDWIGSHAFEN, near 41.5°N, 34.7°W, were treated to 45-kt winds and swells up to 20 ft. The SKAUBORG was pounded by the strongest wind of the storm--48 kt--near 40.7°N, 27.5°W, at 0000 on the 19th. The waves were 11.5 ft at that time and place. The LOW moved southeastward and, at 1200 on the 19th, was about 360 mi west of Portugal. The central pressure was 984 mb. It had absorbed several LOW centers that were in the area. The LYMINGE, about 600 mi to the northwest, had 40-kt gales, and the seas were 26 ft. On the 20th, the LOW was tracking northerly again, and, on the 21st, executed a loop near 50°N, 16.5°W. The LOW was now rapidly filling, and stationary near 52.5°N, 15°W, on the 22d and 23d, prior to disappearing from the charts on the 24th.

Two LOWS were the primary systems in the eastern part of North America, on the 28th. One was centered in Illinois and another near Cape Chidley. At 0000 on the 29th, a new LOW developed over the St. Lawrence River, just north of Lake Ontario. The storm moved up the river, and was west of Anticosti Island, at 999 mb, at 1200 on the 29th. A long, narrow ridge of high pressure, with several centers, extended from northern Greenland southward. This resulted in a tight gradient along and off the coast. The NORDVIKINGUR, northwest of Kap Farvel, was awash with heavy, continuous rain blown by 45-kt gales. The VGBZ, south of Newfoundland, reported 35-kt southerly winds. Twelve hours later at 0000 on the 30th, the VGBZ, in the same area, was tossed by gales that had increased to 45 kt. The LOW had moved to near Hopedale, and Ocean Station Vessel "B" experienced 35-kt winds, 12-ft seas, and rain. On the 31st, the high-pressure ridge began to give way between southern Greenland and Newfoundland, allowing the front to swing eastward in that area. The PENQUER, near 48.5°N, 39°W, was in the cold frontal boundary, and had 40-kt winds. About 200 mi to the north, the IDEFJORD had to contend with winds of only 35 kt. As the original LOW moved up the Davis Strait, and the front swept eastward on the 31st, a new LOW formed on the front, east of Kap Farvel. The new LOW moved eastward with the front, as the old LOW dissipated near Frobisher.

A curious event was noted in the gale tables for May. For 2 days, a ship reported very high swells off the coast of Columbia, but the weather charts did not indicate any apparent cause. No weather system was within thousands of miles. The Azores High was centered about 35°N, 32°W, the circulation was from the east, and the winds, easterly to northeasterly. At 1800 on the 29th, near 11.3°N, 75.6°W, the HINNITES reported 35-kt gales from 060° and 26-ft swells from 060°. The wind seas were reported as

6.5 ft. Twelve hours later, at 0600 on the 30th, near 11.9°N, 74°W, the winds were 40 kt, seas 6.5 ft, and the swells 32.5 ft from the northeast. Another ship, the HADRA, near 11°N, 76.5°W, found 25-kt winds, 8-ft seas, and 23-ft swells, at 1200 on the 29th. Other ships in the southern Caribbean Sea, some distance away, reported 20- to 30-kt winds and 5- to 10-ft seas and swells.

Casualties--All North Atlantic casualties except two were due to ice, and St. John's, Newfoundland, was busy. The Canadian tanker SEA TRANSPORT (3,884 tons) sustained a small hole in her hull due to ice off Cape Race. The Finnish bulk carrier WASA (14,822 tons), on a voyage from Seven Islands to Newport, England, arrived at Halifax on the 5th with a hole in the forepeak tank due to contact with ice. The British motor vessel HELEN MILLER (3,334 tons) arrived at St. John's on the 6th with ice damage to her bulbous bow. The Cypriot NAVI CHAMPION struck an iceberg near the coast of Newfoundland on the 7th, and ruptured 4 m in the forepeak. The Spanish motor vessel MONTE ABRIL (5,248 tons) put into St. John's on the 16th with propellor damage due to ice. The 11,312-ton Panamanian bulk carrier MARITIME PIONEER collided with a German coastal vessel in dense fog off Plymouth, England. The coastal vessel sank and spilled containers into the sea. The 6,680-ton CAPTAIN NIKO sank in the English Channel on May 4, after cargo shifted during a gale. One crew member was reported killed.

SMOOTH LOG, JUNE 1973--The mean pressure pattern in the North Atlantic this month was generally shifted northward and eastward. The gradient was also more intense, as the pressure of the Icelandic Low was deeper and the pressure of the Azores High was greater than normal. The 1006-mb Icelandic Low was centered over Iceland (where else?). This was approximately 1,200 mi northeast of its 1010.5-mb climatology position for June, which is on the coast of Labrador. The 1026-mb Azores High was over the Azores Islands near 39°N, 28°W, or about 600 mi northeast of its 1023.8-mb normal position. Although shifted and more intense, the basic pattern was near normal, a relatively small Low in the northern latitudes and a large High across the temperate latitudes. The pressure along the U.S. East Coast was normal, but higher pressure of about 4 mb covered most of Europe.

The total storm tracks were more numerous than normal, but were generally weak and diffuse. The storms moving across Canada and the Davis Strait-Baffin Bay area seemed to lack direction, moving in circles and loops, and, in general, did not move any further east than Greenland. The storms that came out the New England and Newfoundland area moved northeastward, over or east of Iceland and then northward. These followed the climatic path until the northward turn in the vicinity of Iceland. Normally, the tracks continue with a more easterly component. This is in agreement with the higher average pressure over the European area. The storms out of the U.S. Southeast and in the Mediterranean Sea were insignificant.

The departures from normal were closely alined with the pressure centers and storm tracks. A negative 7-mb anomaly was centered over Iceland in conjunction with the location of the Icelandic Low. The only other significant negative anomaly was 5 mb near Winnipeg, Canada. A ridge of positive departure with a 7-mb center, about 600 mi west of the Brest Peninsula, stretched northeastward from the central Atlantic across England and into the U.S.S.R. Positive 3- and 4-mb anomalies were centered both north and south of Newfoundland, respectively.

No tropical cyclones occurred this month. Normally one tropical cyclone can be expected in June each 2 yr, and half will reach hurricane intensity.

This appears to be a continuation or reoccurrence of the wind and wave reports, north of Colombia, South America, that were noticed and commented on in the May Smooth Log. Three ships mailed weather reports for the 4th, 5th, and 6th, indicating winds of 35 to 40 kt, seas of 7 to 10 ft, and swells of 10 to 16.5 ft. The SEATRAIN OHIO measured 40-kt winds on the 4th and 5th, near 13.6°N, 72.9°W, and 15°N, 70.7°W, respectively. Seas were 8 ft both days, with swells of 13 and 16.5 ft. On the 5th, the SILVER STONE reported 35-kt winds and 10-ft seas near 12°N, 74°W, with a moderate rain shower. On the 6th, the SANTA MERCEDES also reported 35-kt gales, near 12.1°N, 72.8°W, with 6.5-ft seas and 10-ft swells. Except for the rain shower, the present weather indicated fair conditions and the analysis did not appear to suggest any tropical disturbance.

This LOW appears to have formed near 41°N, 50°W, at 0000 on the 6th, when two weak LOWS, one to the north and one to the west, combined into one center. The pressure was 1014 mb at that time. This embryonic circulation was surrounded by multiple high-pressure cells, but 12 hr later it was making a place for itself, as it expanded its influence. The GRIPSHOLM found 35-kt northeasterly winds with rain at 44°N, 43.1°W, 140 mi north of the center. As the LOW moved northeastward, it passed south and east of Ocean Station Vessel "D," at 0000 on the 7th, and presented her with 40-kt northerly winds and 12-ft seas. The storm was deepening at 1200 on the 7th, near 45°N, 40°W, with a pressure of 1003 mb. It started curving westerly as it traced an S-shaped track, between the 6th and the 10th. At 1200 on the 7th, Ocean Station Vessel "D" reported 35-kt gales, and the ERLANGEN, at 42.7°N, 42.2°W, was buffeted by 40-kt gales. At 0000 on the 8th, "D" was still being stung by 40-kt gales as she and the storm circled each other. In the westerly movement the LOW filled considerably and weakened as it appeared the HIGHS would defeat her. The central pressure had risen to 1017 mb at 1200 on the 8th.

Although weakened, the storm persisted, and, late on the 9th, started again on a northeasterly track. At 1800 on the 9th, Ocean Station Vessel "D" again measured 35-kt gales. At this time, the storm came under the influence of more zonal upper air flow and started to speed off to the east. The 1005-mb tempest was at 54.5°N, 29.5°W at 1200 on the 11th. The DOCTOR LYKES, 300 mi to the south, received 35-kt gales and 16-ft seas along the cold front.

The 992-mb storm passed just north of the Hebrides late on the 12th, and 45-kt winds were reported. As

the storm passed up the Norwegian Coast, Ocean Station Vessel "M" reported 30-kt gales, and coastal stations measured 30- to 40-kt gales. The LOW moved across the Barents Sea, the Kara Sea, and into the Laptev Sea (all in the Arctic Ocean), where it finally dissipated on the 22d.

The 6th was a good day for storms in the Atlantic, not ships. A little history first. Earlier in the month, a LOW moved out of Newfoundland toward Greenland. As it approached the southern tip, it split into two centers. One moved through the Denmark Strait on the 5th and left an elongated trough. It was in this trough that the 994-mb LOW that concerns us formed, at 1200 on the 6th. The center moved eastward and was north of Iceland late on the 7th. Early on the 7th, the ANNA JOHANNE, NIKOLAI KONONOV, and SAIMA DAN reported 35-kt gales. All these ships were south of the LOW, stretching from near Kap Farvel to near the Faeroe Islands. The LOW continued to speed off to the northeast and was absorbed into another circulation late on the 8th.

A LOW and frontal system, that had occluded, tracked across Canada, and, at 0000 on the 10th, was on the eastern coast. A new LOW formed at the point of occlusion, just south of Gaspe Peninsula in New Brunswick. As the 998-mb LOW moved along the south coast of Newfoundland on the 11th, SEDCO "J" reported 35-kt gales. On the 12th, the LOW dawdled off the east coast as it deepened to 988-mb. The TRENTWOOD was bucking 35-kt winds, 18-ft seas, and 23-ft swells near 52.5°N, 49.6°W, to the north of the center.

The storm picked up speed and moved on a southeasterly course for about 24 hr, before turning northeastward. Early on the 13th, Ocean Station Vessel "C" was pounded by 45-kt winds. At midday CHARLIE was still measuring 40-kt sustained winds, as was the TRENTWOOD to the north of the center. South of the storm the LUDWIGSHAFEN and the VISURGIS reported 35-kt gales.

The LOW was located near 50.2°N, 35°W at 1200 on the 14th. The TRENTWOOD, which was keeping pace with the storm, had 40-kt gales and waves of 23 ft. The MANCHESTER CONCEPT and MANCHESTER COURAGE both found 35-kt gales north of the LOW. On the 15th, the RAMBURGH CASTLE, 500 mi south of the center, encountered 45-kt winds. Later that day, two ships that could not be identified reported 35- and 40-kt gales south of the center.

On the 17th, the LOW executed a loop southwest of Iceland, as another LOW raced around its periphery and became the dominant feature late on the 18th.

Monster of the Month--A stationary front stretched east-west across the Great Lakes on the 16th, and a wave developed east of Lake Huron that day. On the western end of Lake Superior, the JOHN DYKSTRA measured 35-kt winds and 5-ft seas in a pouring rain. The wave raced along the front, and, by 0000 on the 17th, was west of Cape Cod. As it passed off the coast and over the water, it deepened rapidly, and was 990 mb off Nova Scotia at 1200. The ATLANTIC CHAMPAGNE was rolled by a 35-kt wind on her port side, in the warm sector of the system. The SEATRAIN OHIO was tossed by 16.5-ft seas and 24.5-ft swells from the north, near 40°N, 69°W. Further to the east, the ARALUCK was embraced by 43-kt winds and the USCGC BOUTWELL measured 40-kt gales.

The next day, the pressure had plummeted to 978 mb. The HAMBURG had 40-kt gales as the front passed. In the next 24 hr, the LOW moved across Newfoundland, with the following ships reporting 35- to 40-kt gales: the ARALUCK, PASSAT, BOCKENHAIM, and the USCGC EVERGREEN, in addition to the GSAR and the 5PFH.

At 1200 on the 19th, the 989-mb LOW was at 52°N, 48°W. The JOHN CABOT, about 150 mi south of the center, was pummeled by 45-kt gales. Ocean Station Vessels "C" and "D" had 35- and 40-kt gales, with seas running about 15 ft. SEDCO I was blasted by 40-kt winds. On the 21st, the LOW continued its march toward the northeast, and was near 59°N, 32°W at 1200. The TOPSDALSFJORD, at 55.1°N, 48.6°W, was headed into 50-kt storm winds as a second LOW moved off the Labrador coast and tightened the gradient. On the 22d, the LOW moved over Iceland and deteriorated rapidly as the circulation broke down because of the interaction of the two LOWS.

This LOW is mainly significant because of its location, rather than the number of high wind reports.

The front associated with the storm described above was ahead of the center, and stretched southwestward between two HIGH centers. On the 20th, a 1020-mb wave formed near 34.5°N, 50.4°W. This was between the two HIGHS and south of their centers. The LOW progressed northeastward for the next 24 hr and deepened to 1012 mb. At 1200 on the 21st, the SACRAMENTO, at 37.5°N, 45°W, about 100 mi north of the center, was lashed by 40-kt winds and heavy rain. By the 22d, the western HIGH extended eastward in an elongated shape, like a banana, pushing the LOW to the south. The LOW tried to hang on and fought a good battle, but the building HIGH was too powerful. The last vestige was an inverted trough on the 0000 chart of the 23d.

This last storm of June, like the one to the south, was born as a wave on a stationary front on the 28th. It was lucky, with a good chance for survival, because the only high-pressure area was south of it. The LOW matured fast; by 0000 on the 29th, the pressure had dropped to 990 mb and a good circulation was developing. The center was near 55°N, 35°W. Ocean Station Vessel "C" received 40-kt gales. Twelve hours later, the pressure was 972 mb, and ships reported gale-force winds--DAGHESTAN, EDITH HOWALDT RUSS, SILVERSAND, and faithful Ocean Station Vessel "C."

The storm was due south of Iceland on the 30th. The GRIPSHOLM, 500 mi to the south, near 50.5°N, 20°W, was battered by 50-kt winds and 38-ft seas. North of her, Ocean Station Vessel "J" contended with only 35-kt gales and 18-ft seas. The BELLA MAERSK, near 60°N 26.5°W, plowed through 23-ft seas, driven by 36-kt gales.

As the LOW passed over the eastern tip of Iceland on July 1, the system was weakening, and the central pressure had risen to 986 mb. The wind reports had dropped off considerably, with only breezes plotted on the chart. Late in the day, a new LOW broke off to the north of the main center and moved northeastward, while the original center remained stationary over the south coast of Iceland until the 2d, where it perished.

Casualties--Thunderstorms and fog were the culprits this month. Two lake freighters, the FRANK PURNELL and the SYLVANIA, collided in heavy fog on Lake Erie, at the mouth of the Detroit River, early on the 2d. The Norwegian tanker BOW ELM (6,792 tons) and the British tanker IRVING STREAM (15,185 tons) tried to occupy the same anchorage at the entrance to St. John's, Newfoundland, harbor, during heavy fog on the 21st. The Panamanian steamer PACIFIC ALLIANCE (10,637 tons) went aground near Cabo San Antonio, Cuba, during a storm, prior to the 14th. The 58,277-ton Liberian tanker CONOCO BRITANNIA was holed during fog in the Humber Estuary.

A series of violent thunderstorms on the 9th overturned hundreds of boats at Marblehead and Salem Harbors, Mass. Coast Guard cutters and helicopters pulled some 200 persons from the water. Logan Airport recorded 42-kt winds, but wind gusts over the harbors were estimated at up to 70 kt. Thunderstorms over Lake Michigan claimed three lives, as sailing and fishing boats were capsized.

Smooth Log, North Pacific Weather

May and June 1973

SMOOTH LOG, MAY 1973--The cyclone activity was above normal over the northern ocean from Japan to the Gulf of Alaska, and much above normal in the Gulf of Alaska. This was partially due to a more easterly track, which diverted some of the storms to the Gulf of Alaska that normally track into the Bering Sea. Two cyclones originated in the Bering Sea and moved to the Gulf of Alaska. A track out of Manchuria, across Sakhalin Island, and into the Bering Sea curved more northerly across the Sea of Okhotsk into Siberia instead of the Bering Sea.

The pressure pattern was near normal, except the Aleutian Low was centered south of Kodiak Island, rather than near the middle of the Bering Sea, as climatology indicates. The central pressure was 1002 mb, 6.5 mb lower than normal. The Pacific High was normally positioned and 2 mb higher than average, at 1024 mb.

The primary feature in the anomaly pattern was a negative 11-mb center in the Gulf of Alaska, south of Kodiak Island. Its position was very nearly identical to the Aleutian Low. The western part of the ocean off Japan ranged from 1- to 4-mb below average. Positive 4-mb anomalies were centered off the U. S. West Coast and in the central Pacific. Two small 3-mb positive anomalies straddled the Kamchatka Peninsula.

In the eastern North Pacific, three tropical cyclones can be expected each 7 yr, with all three reaching hurricane intensity. The western North Pacific averages six tropical storms each 5 yr, and 3/4 of these reach typhoon intensity. This has been a truly exceptional year, for none occurred in either ocean this month, and the first tropical cyclone of the year did not occur until June 1, in the eastern North Pacific.

The high wind and waves that struck the GUAM BEAR off the California coast, at 37.2°N, 126.5°W, were connected with an anticyclone, rather than a cyclone. A 1026-mb HIGH was located near 32°N, 135°W, with what appeared to be a normal gradient between its center and the coast; but at 0000 on the 1st, the GUAM BEAR was engulfed by 51-kt winds, accompanied by 19.5-ft seas and 24.5-ft swells.

Monster of the Month--This storm system entered the Yellow Sea on the 1st, as a fully developed 992-mb LOW. As it moved south of Korea and across Japan, it slowly filled to 997 mb. The 989-ton MEIHO MARU sank in Kii Strait on the 2d, due to shifting cargo in rough seas. The crew was rescued. On the 0000 chart of the 3d, a second 997-mb LOW was indicated over Hokkaido, Japan. This was to become the primary cyclone. The HAKUKO MARU, near 40°N, 149°E, was caught by 40-kt gales. During the next 24 hr, the LOW consolidated its circulation and moved up the Kuril Islands. The CHEVRON AMSTERDAM, KENSHO MARU, and the SHIMA MARU reported 35- to 40-kt gales ahead of the front. By 1200 on the 4th, the LOW had deepened to 980 mb, and Ostrov Simushir was blasted by 70-kt hurricane-force winds. The LOW was located about 180 mi to the north.

On the 5th (fig. 31), the LOW came under the influence of

Figure 31.--The apparent center of the LOW on this satellite picture at 2223 on the 4th is located near 49°N, 162°E. Another LOW is centered over the Alaska Peninsula. Note that the Bering Strait is blocked with ice.

the upper air zonal flow and sped off to the east. As it raced eastward, north of the Aleutians, the HOLLANDS BURCHT and the JAPAN MAPLE reported 35-kt gales and 12- to 15-ft seas in the southwest quadrant. By 0000 on the 7th, the 972-mb LOW was south of Shumagin Island, near 50°N, 160°W. The HIRO MARU and RHEIN MARU were hit by 35-kt gales on both sides of the Aleutian Islands. Late that day, the HONSHU MARU, near 46.9°N, 155.6°W, measured only 35-kt westerly gales, but she was headed into seas that were 13 ft and swells of 25 ft. The storm slowed considerably on the 8th, when the IMA was bucking 50-kt westerly headwinds and 23-ft swells, near 46°N, 144°W. This was about 500 mi south of the center. Ocean Station Vessel "P," nearer the center, was tossed about by 40-kt gales and 15-ft seas. Twelve hours later, at 1200 on the 8th, "P" still had 40-kt winds, but the seas had increased to 21 ft.

The LOW was idling in the area of 55°N, 145°W and filling rapidly, as another LOW approached from the west and became the primary system in the Gulf of Alaska, on the 10th.

As the previous LOW moved into the Gulf of Alaska, a small 1005-mb LOW developed in the Bering Sea near 57°N, 178°E, late on the 8th. It is slightly unusual for a LOW to develop in the Bering Sea, which is usually where they dissipate. By 0000 on the 10th, the LOW had moved across the Aleutians and, at 996 mb, had almost completely absorbed the circulation of the older system. As the associated front moved past the WORLD PALEGIC, she reported 35-kt gales, as did the SHINYO MARU. The SUMMIT, which was near Shumagin Island, was swept by 50-kt winds and light snow. The IMA, traveling southwestward, was still being rolled and battered by 44-kt gales and 23-ft seas from the northwest. Also adding to her misery were 32.5-ft swells from the west. These continued for the next 6 to 12 hr.

The storm had slowed considerably in its easterly track, but was deepening, and at 1200 on the 11th was near 50°N, 148°W, where it became stationary. The HAMBURG EXPRESS, 400 mi to the southwest, had 40-kt winds. Twelve hours later, three ships reported 35-kt gales in the north and east quadrants of the storm.

The original front with the LOW had moved far ahead of the circulation, and a new front developed in the trough. With this new front, another LOW had developed by 1200 on the 12th. Within 12 hr this LOW became the predominant one. The PACEMPEROR was hit by 50-kt winds 750 mi to the south. The OCEAN PROGRESS, near 35°N, 160°W, and the FEDERAL MACKENZIE, near 50°N, 158°W, both had 40-kt gales. The center moved northward as another LOW developed on the front, late on the 13th, and rotated around the storm. The WASHINGTON MAIL found 50-kt quartering winds near 54.4°N, 150.5°W. On the 15th, the LOS ANGELES and the RYOKU MARU found 40- to 50-kt winds. By late on the 15th, the LOW could no longer be found on the chart.

The ancestry of this LOW goes back to the 15th, to the Yellow Sea, where a wave formed and tracked south of Japan. This wave and front were south of another wave and frontal system that moved northeastward out of the Sea of Japan. The BRINTON LYKES was whipped by 45-kt gales near 30.9°N, 132.8°E, as the LOW passed just north of her position. The LOW moved toward the east, then northeast, as it moved around the periphery of the northern system. As this LOW neared midocean on the 21st, it was very shallow and could not make it across the upper air ridge. Later on the 21st, a new surface wave appeared on the front, on the east side of the ridge. This LOW developed as it moved into the Gulf of Alaska.

At 0000 on the 22d, the LOW was near 46.5°N, 170.5°W, with a pressure of 1002 mb. For the next 24 hr the LOW raced eastward at about 45 kt, and at 0000 on the 23d was near 47.5°N, 144.5°W. South of the center, the KUSUNOKI MARU and the TASSOS V had 35-kt gales. As the LOW turned northward, it slowed to a crawl. Gale winds were reported on the Oregon-Washington coast. Winds up to 40-kt were reported by the NANSHO MARU, Ocean Station Vessel "P," and the TRIUMPH, around the southern half of the storm. The GALVESTON, near 53.4°N, 136.2°W, was bounced by 24-ft swells, and the ARCO PRUDHOE BAY, near 53.8°N, 141.5°W, had it even tougher with 29.5-ft seas and 32.5-ft swells. As the LOW moved toward Capt St. Elias, it rapidly lost its punch. By the 26th it no longer existed.

This storm was born in an inverted trough about 450 mi east of Tokyo on the 24th. It started to develop rapidly, and the KOYO MARU No. 11 found a 40-kt wind band west of the center. This first effort was short-lived, as the high pressure on each side exerted its influence. During this time, the center burrowed northward, finally breaking through to the north side of the HIGH on the 27th. The CHICAGO MARU and the KIYOSHIO MARU reported 40-kt gales on both sides of the LOW. Heavy rain was falling in the north and west quadrants. The WASHINGTON MAIL, at 41.1°N, 151.7°E, was still having a rough voyage, with 45-kt northwesterly winds and 20-ft seas. At this time, the storm started moving eastward. The HIGH to the east started to move eastward, and the LOW's circulation expanded as it followed. By the 30th, the HIGH had developed to 1036 mb, and the LOW was diverted northward. Light winds were reported, but no reports were available for the area of tightest gradient. The storm entered the Bering Sea, on the 31st, and rapidly filled.

This last storm of the month had very inconspicuous beginnings as a weak wave on a weak front, in the Yellow Sea near Korea, on the 28th. It moved across the Sea of Japan, and was east of Honshu at 1200 on the 29th. The pressure was now 1000 mb. The MEGUROSAN MARU reported rain and 40-kt gales, near 38.5°N, 157.3°E. The LOW was moving northeastward slowly, and the front was well north and east of the center. Two ships encountered 35-kt gales ahead of the occlusion. They were the DAISHOWA VENTURE and the FEDERAL MACKENZIE.

The LOW idled slowly along the Kuril Islands and on June 3 developed a new life. Its circulation increased, and the pressure dropped. At 0000 on the 4th, the 988-mb center was near 49.5°N, 177°E. On the 4th, four ships found 35-kt winds in an arc about 450 mi south of the center. They were the LOUISIANA MARU, MINETAMA MARU, NIPPON MARU, and the REGENT VANDA. As the storm moved south of Unimak Island on the 5th, with a pressure of 982 mb, the AMERICA MARU was cooled by 35-kt gales and

swells of 16 ft. This was the height of the storm, as it started to disintegrate as it moved deeper into the Gulf of Alaska. Although it was battered by two frontal waves and a HIGH, it tenaciously persisted until the 10th.

By coincidence, the month ended on the same note that it began, with the same ship. The GUAM BEAR was headed back to the U.S. West Coast on the 31st. Again, a large HIGH (1039 mb) was centered off the California-Oregon coast. At 1200 on the 31st, the GUAM BEAR reported 35-kt winds near 36.5°N, 129.8°W. By 1800, near 36.8°N, 128.3°W, she was bucking 51-kt northerly winds, driving 19.5-ft seas, and 24.5-ft swells.

Casualties--Violent rainstorms with high winds raked havoc over Japan on the 8th. A 503-ton South Korean freighter, the NEW HAE DONG HO, capsized, killing two crewmembers. Two other vessels were reported to have sunk. A total of 9 were reported dead, and 11 missing. The Australian ALLUNGA (14,072 tons) and the Indian VISHVA SHAKTI (6,467 tons) collided in fog in the Juan de Fuca Strait on the 16th. On the 19th, the 50-ton tugboat No. 12 KYOSEI MARU capsized off the port of Kashima, hit by strong beam waves. One crewmember was missing.

SMOOTH LOG, JUNE 1973--The storm track pattern for the month was like a tracing of the climatological paths that was misalined, causing the tracks to be 5° latitude further south. There was even a storm track near the Bering Strait to match the climatic track. Without statistically analyzing the dates, it appears that there were more storms the last half of the month. For June, the total number was slightly above normal. In the western ocean, the majority of the storms formed in a narrow band between Kyushu and 25°N. One storm emigrated from northern Manchuria to Alaska. In midocean, the path was very diffuse between 30°N and 50°N, but east of 180° it narrows again, entering the Gulf of Alaska. One LOW got off the beaten path, and it was "California or Bust;" fortunately, it was "Bust."

The main feature of the pressure pattern was the Pacific High, in accordance with climatology. The 1025-mb High was centered near 33°N, 142°W, about 500 mi east-southeast of the normal 1023.8-mb position of 36°N, 150°W. In June, the Aleutian Low is normally a trough with an axis stretching from the Bering Sea to central India. This month there was a closed 1010-mb center in the Gulf of Alaska, near 53°N, 147°W. The area generally bounded by 40°N to 60°N and 160°W to 150°E had a very diffuse pressure pattern and flat gradient. It contained three Highs and two Lows, ranging from a maximum of 1014 mb to a minimum of 1012 mb.

There were three major areas of negative anomalies. The largest and most significant was a minus 7-mb center at 51°N, 143°W. Associated with it was a minus 5-mb in Yukon, Canada. The third was a long, narrow area that averaged 4 mb below normal. It stretched from Hai-nan Island to about 38°N, 175°W, and averaged 5° latitude in width. A 2- to 4-mb positive departure occupied the Bering Sea. Above-normal pressure of 2 to 4 mb occupied a triangle in the eastern ocean, with apexes near Hawaii, Puget Sound, and an undefined point south of Baja California.

There were three tropical cyclones in the eastern North Pacific this month; hurricane Ava, tropical storm Bernice, and tropical storm Claudia. A new record was set, with no tropical cyclones in the western North Pacific since December 1972.

A large LOW was centered near 50°N, 156°W, at 0000 on the 6th. A front extended from Queen Charlotte Islands southwestward, and then westward along 35°N. On this front, a 1013-mb wave developed near 37°N, 175°W. The wave raced northeastward at about 45 kt, and was at 42.5°N, 152°W at 0000 on the 7th. The MORMACGLEN, 180 mi south of the 1008-mb wave apex, reported 35-kt southwesterly gales. The fast-moving wave continued its headlong rush until it clashed with the Coast Mountains of British Columbia at 0600 on the 8th. As the cold front passed its position, about 300 mi off Portland, the FURMAN reported moderate rain and 35-kt winds.

On that same stationary front, another wave developed at 0000 on the 7th. It, too, raced eastward, and the BUENOS AIRES MARU encountered heavy rain and 35-kt gales in the warm quadrant on the 9th.

Another LOW that had moved southeastward from Kamchatka Peninsula moved in behind this LOW and slowed its advance. The TOYOTA MARU, near 41.9°N, 175.2°W, was hit by 41-kt gales and 23-ft swells. A third LOW developed east of the first two, and, at 1200 on the 9th, was near 42.5°N, 162°W. This last LOW moved northeastward near 49°N, 146°W at 0000 on the 11th. The NEW JERSEY MARU was suffering 35-kt northwesterly winds on her westerly course at 25 kt. She also reported 13-ft seas and swells. The AVILA, at 53°N, 139.1°W, was whipped by 50-kt storm winds. At 1200, the LOW overtook and absorbed another LOW, which was lazing along. The central pressure was then 984 mb. The PHILADELPHIA, off Vancouver Island, found 35- and 40-kt gales for about 24 hr, with seas as high as 16.5 ft and swells up to 19.5 ft. On the 12th, Ocean Station Vessel "P" and another ship near 46°N, 146.5°W reported a 45-kt battering from the northwest. Late on the 12th and early on the 13th, the LOW made a small loop near 51°N, 136°W. On the 12th, the FAIRSEA and the IMA were both pounded by 50-kt winds. On the 13th, the IMA struggled against 55-kt winds and 23-ft seas, near 46.5°N, 138.6°W, and the KANFOKA MARU reported 50-kt winds. This pause allowed the winds to build up the sea and swell, and the SUZUKAWA MARU, due west of the center, reported 16-ft seas and 18-ft swells. Ocean Station Vessel "P" was still receiving 40-kt gales.

The LOW slowly approached the coast of Washington State and, on the 15th, washed out against the mountains.

During this time, the pressure pattern across the North Pacific was diffuse, with numerous relatively weak HIGHS and LOWS. This 1012-mb LOW formed on the 9th in a weak circulation area between two HIGHS and a LOW. The JFLI helped the meteorologist locate it with her report of 35-kt gales. The TRENTON, near 35°N, 142°E, found 45-kt winds.

For the next 48 hr, the LOW drifted eastward, gaining organization. At 1200 on the 11th, the LOW was at 37°N, 167.7°E. Twelve hours later, she passed under a 500-mb pressure surface trough line, and was caught up in the zonal westerlies.

The KASHU was hit by 40-kt southerly winds, west of the center, as the occluded front passed. Twenty-

four hours later, at 0000 on the 13th, the 990-mb LOW was at 47.5°N, 174°W. The TOYOTA MARU No. 15, at 42.5°N, 161°W, went through a 40-kt car wash. On opposite sides of the center, the RYUSHO MARU and SHUKO MARU were lashed by 35-kt gales. Except for typhoons, this was probably the stormiest day on the North Pacific this month, at least as far as wind was concerned. Both this storm and the previous LOW had winds of 40-kt or greater on this day.

The LOW now moved into the Gulf of Alaska, towards the Olympic Peninsula, where it collapsed on the 17th.

The specific LOW of concern here formed on the 20th, but its ancestry goes back more than a week, to the 10th. A 1005-mb wave formed about 400 mi south of Kyushu, Japan. It moved northeastward very slowly until the 13th. At that time, it was about 120 mi south of Tokyo, where it turned more easterly and started to gain strength. On the 15th, the 994-mb LOW was near 39°N, 155°E and curving toward the north. Another wave moved in from the west, and the two consolidated. The GENEI MARU and the TERUKAWA MARU reported 35- and 40-kt winds on the 16th. A 1038-mb HIGH, near Adak Island, was blocking its forward movement. On the 17th, the MIDAS RHEIN battled 45-kt gales on her port side as the LOW passed ahead of her course. During this period, the forward movement was about 12 kt.

The HIGH finally started breaking down and moving southeastward on the 18th. The frontal system had moved far ahead of the parent LOW, and another LOW developed at the point of occlusion, near 49°N, 176°W. At 1200 on the 20th. the two LOWS merged near 51.5°N, 171°W, at 984 mb. The CALIFORNIA, which was sailing east, was keeping ahead of the system and periodically receiving gale-force winds with a southern component. On the 21st, the strongest winds were in the northeast quadrant. Some Aleutian stations reported 35- to 40-kt winds, and the JUJU MARU No. 2 was rocked by 40-kt gales off Dutch Harbor.

The 985-mb LOW had turned southeastward as it entered the Gulf of Alaska and, at 1200 on the 22d, was at 48°N, 145°W. The OREGON MAIL, 180 mi north of the center, was bucking 45-kt bow winds. With her 20-kt speed, this meant an effective hurricane-force wind was blowing across her decks.

As several of the other storms did this month, this LOW executed a large loop. It visited the vicinity of Ocean Station "P" for 4 days before heading for the coast. During this period, it gradually filled, and was a weakling of 1018 mb when it met its end near Queen Charlotte Islands.

A large HIGH was developing off the Oregon coast, in the vicinity of 45°N, 145°W, as the above storm disintegrated. A tight pressure gradient developed along the coast from around San Francisco northward on the 29th and 30th. The PRESIDENT JEFFERSON ran into gale-force winds north of San Francisco as she traveled northwestward.

This was the first tropical cyclone in the North Pacific this year, and she was a beauty. Hurricane Ava was one of the most vigorous and sophisticatedly measured storms on record in the eastern North Pacific. She started as a depression on June 1, near 11.4°N, 95.4W, about 250 mi south of Salina Cruz, Mexico. The depression was nearly stationary in its formative stage, but began moving slowly westward after becoming a tropical storm at 1800 on the 2d. Ava was located by satellite and ship reports from the HOEGH TROTTER, JOSEPH LYKES, and the VOLNAY. The reports indicated the presence of a cyclonic circulation, 30-kt winds, and a pressure of 1000.6 mb about 100 mi from the center. Slow westward movement continued with intensification.

The storm became a hurricane by the afternoon of the 3d, when Air Force reconnaissance from Puerto Rico measured winds of 70 kt, with gusts to 95 kt near the center, at 12.6°N, 96.6°W, about 180 mi south of Port Angeles, Mexico. Winds reached 100 kt on the afternoon of the 5th; on the 6th, 137 kt were measured by NOAA aircraft; and Air Force radiosonde equipment, dropped into the eye, determined a central pressure of 915 mb (27.02 in), 650 mi southwest of Acapulco. At this time, the westward movement had increased to 17 kt.

Skylab passed near hurricane Ava, and the storm was almost directly under satellite NOAA-2 at its peak intensity. Skylab and NOAA aircraft investigating the storm were both equipped with unique sensing devices, which enabled them to measure sea heights of 40 ft by radiometric means, the first hurricane wave height measurement by remote sensors. The NOAA aircraft measurements also indicated how rapidly winds increased toward the eye of the storm. In 1 min, 50 sec--4 mi flight distance--winds increased from 60 to 137 kt, and in only 37 sec--a flight distance of 2 mi--winds increased from 90 to 137 kt. A circular closed-wall eye was observed by the Air Force reconnaissance crew and by the NOAA-2 satellite.

The peak intensity of the hurricane was reached on the 6th, near 11.9°N, 107.5°W, and gradual deterioration continued for the next 6 days. On the 7th, a wind of 120 kt; on the 8th, 100 kt; and on the 9th, 90 kt were measured by reconnaissance. The hurricane weakened to a 60-kt tropical storm near 16.5°N, 127°W, late on the 9th; to 40 kt on the 10th; and became a depression on the 11th. By the 12th, the remains entered the trades as an easterly wave.

Vessels whose observations aided in locating and tracking the storm were: ACAVUS, AKIBASAN MARU, ANDORA, ASHKHABAD, ATENAS, CHEVRON AMSTERDAM, CHEVRON NAPLES, CLARA MAERSK, DELTARECHT, ERISKAY, HERMAN SCHULTE, HOEGH TROTTER, HOLTEF JELL, JOSEPH LYKES, H. R. MACMILLAN, MORNING LIGHT, OAKLAND, SAN MARIN MARU, SEATTLE, SHEAF TYNE, and the WILKAWA. Others not in the AMVER listings included DAGB, DNCT, GAZG, GZSB, JDNQ, JXJT, KFGX, NKFN, and OWIE.

Tropical storm Bernice was first suggested by satellite pictures and ship reports on the 18th, 300 mi south of Ixtepec, Mexico, as a disturbance on the intertropical convergence zone. The disturbed area remained nearly stationary and increased in intensity until becoming a tropical depression at 1800 on the 21st, near 13°N, 97°W, about 180 mi southwest of Salina Cruz. Movement was toward the northwest at 10 to 12 kt.

Development to tropical storm intensity continued during the afternoon, and, by 0000 on the 22d, winds to 40 kt were estimated from satellite pictures, and a

35-kt wind was reported by the HENNITES. Movement continued northwest, with the TARONGA reporting 40-kt winds about 60 mi from the center, at 1200 on the 22d, and Acapulco, 90 mi from the center, indicating 30-kt winds. At 1800, the TARONGA reported 50-kt winds about 30 mi northwest of the center, while another vessel reported a west 40-kt wind about 50 mi southwest of Zihuantaneo, Mexico, suggesting the storm was moving onshore.

Other vessels whose observations helped locate and track the storm were: the EXPORT CHAMPION, LUDWIGSHAFEN, NORMASCAN, SANTA MARIANA, and the STAR HALMANGER. Others were somewhat remote from the center.

Tropical storm Claudia began as a disturbed area noticed on satellite pictures on the 23d, about 300 mi south of San Salvador, near 8°N, 88°W. The area moved westward at about 10 kt to 9°N, 92°W on the 24th. A closed circulation was indicated in satellite pictures, and reports by the SEUCIA, TRENTON, and the STARSTONE centered a weak depression at 10°N, 95°W, by 1800 on the 25th.

Satellite pictures indicated a more northwesterly course between the 25th and 26th, and the depression intensified to a tropical storm with 50-kt winds, near 14°N, 98°W, at 1800 on the 27th. The storm continued north-northwest, but slowed to about 5 kt with maximum winds of 50-kt, until it went onshore about 30 mi east of Acapulco, late on the 28th.

AMVER-listed vessels aiding in locating, tracking, and estimating the intensity of Claudia were: AMERICAN LEGACY, LEMONCORE, MAURICEIN, PACIFIC ERA, SHEAF CREST, STAR COLUMBIA, STARSTONE, SUECIA, TRENTON, UNION SUNRISE, and the ZIM HAFIA.

Casualties--All casualties in the North Pacific were because of fog. The first was a collision, on the afternoon of the 5th, in Juan de Fuca Strait, between the Panamanian ORIENTAL MARINER (14,246 tons) and the Liberian WAYWAY (13,553 tons). On the 20th, the two Greek vessels MARINA L (19,566 tons) and the THEOKEETOR (10,488 tons) collided about 150 mi south of San Diego. The THEOKEETOR sank, but, happily, all of the crew was rescued by the Swedish ship SAN BRUNO. Also on the 20th, the 9,325-ton Japanese ferry MARIMO and the 300-ton fishing boat No. 15 HACHISHIO collided 12 mi off Oyaki Lighthouse. No one was injured.

A rash of collisions (3) occurred on the 29th and 30th, on the Japanese Inland Sea, in dense fog. The evenly matched 293-ton No. 8 FUJI MARU and the 293-ton No. 8 YOSHINO MARU collided near Katayama Island. The 7,017-ton ferryboat ORION collided with the 325-ton tanker SHINKO MARU,1 mi west of Katjitori-noharu Lighthouse. None of the 294 passengers and crew were injured. The unevenly matched 4,850-ton OKUDOGO No. 2, a ferryboat, and the 48-ton YAWATA MARU, a freighter, collided off Kobe. The freighter sank, and the two crew members were rescued from their lifeboat by the crew of the ferryboat. All 187 passengers and 37 crew members on the ferry were safe.

This casualty occurred in the Arabian Sea. The Indian-registered freighter SAUDI (5,973 tons) was capsized by huge waves off the Horn of Africa on the 26th. The U. S. Navy destroyer JONAS INGRAM reported that it and the Israeli LEORA had picked up 43 survivors and 8 bodies.

THE MARINERS WEATHER LOG WELCOMES ARTICLES AND LETTERS FROM MARINERS RELATING TO METEOROLOGY AND OCEANOGRAPHY, INCLUDING THEIR EFFECTS ON SHIP OPERATIONS.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

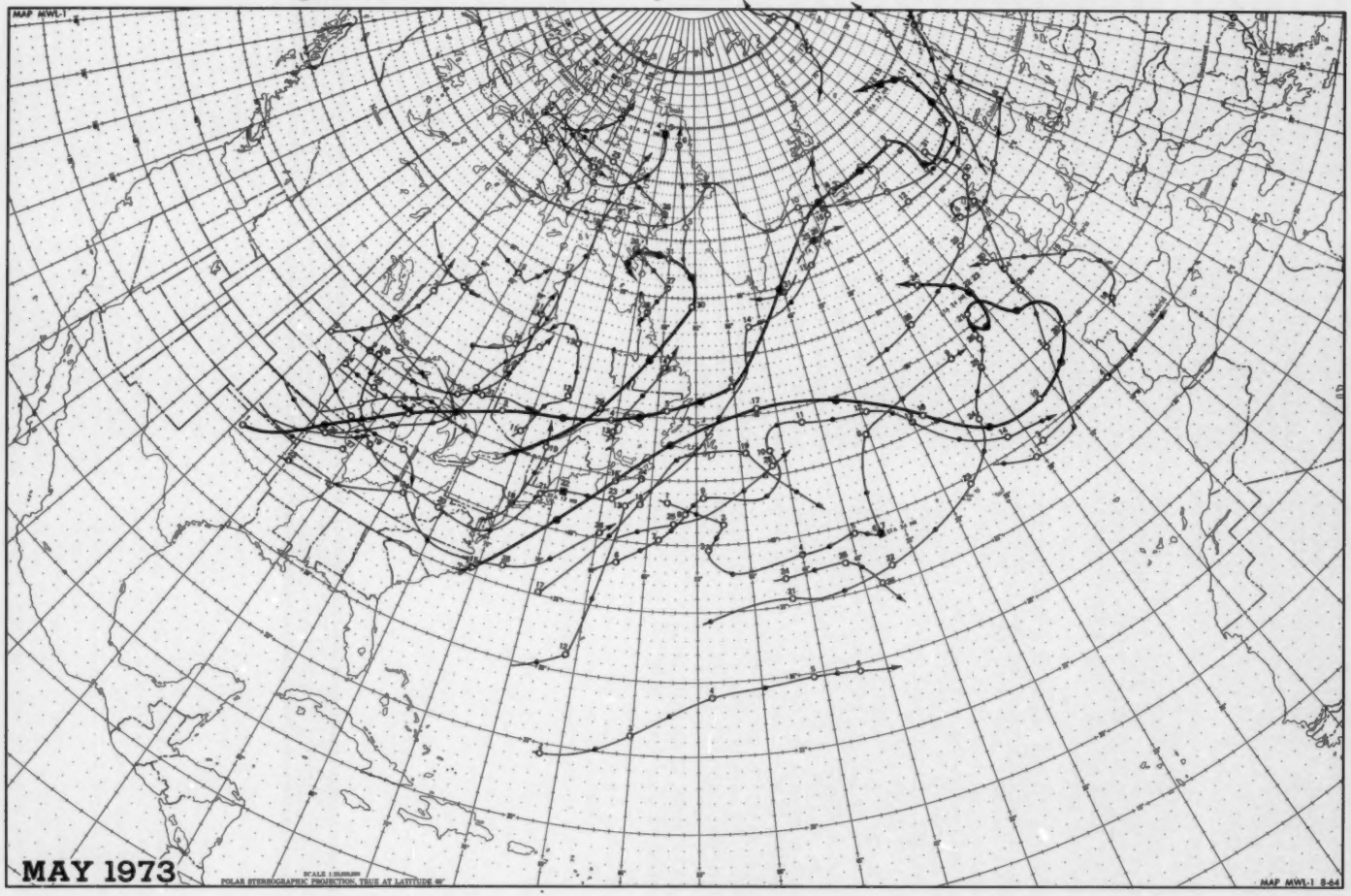

Figure 32.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

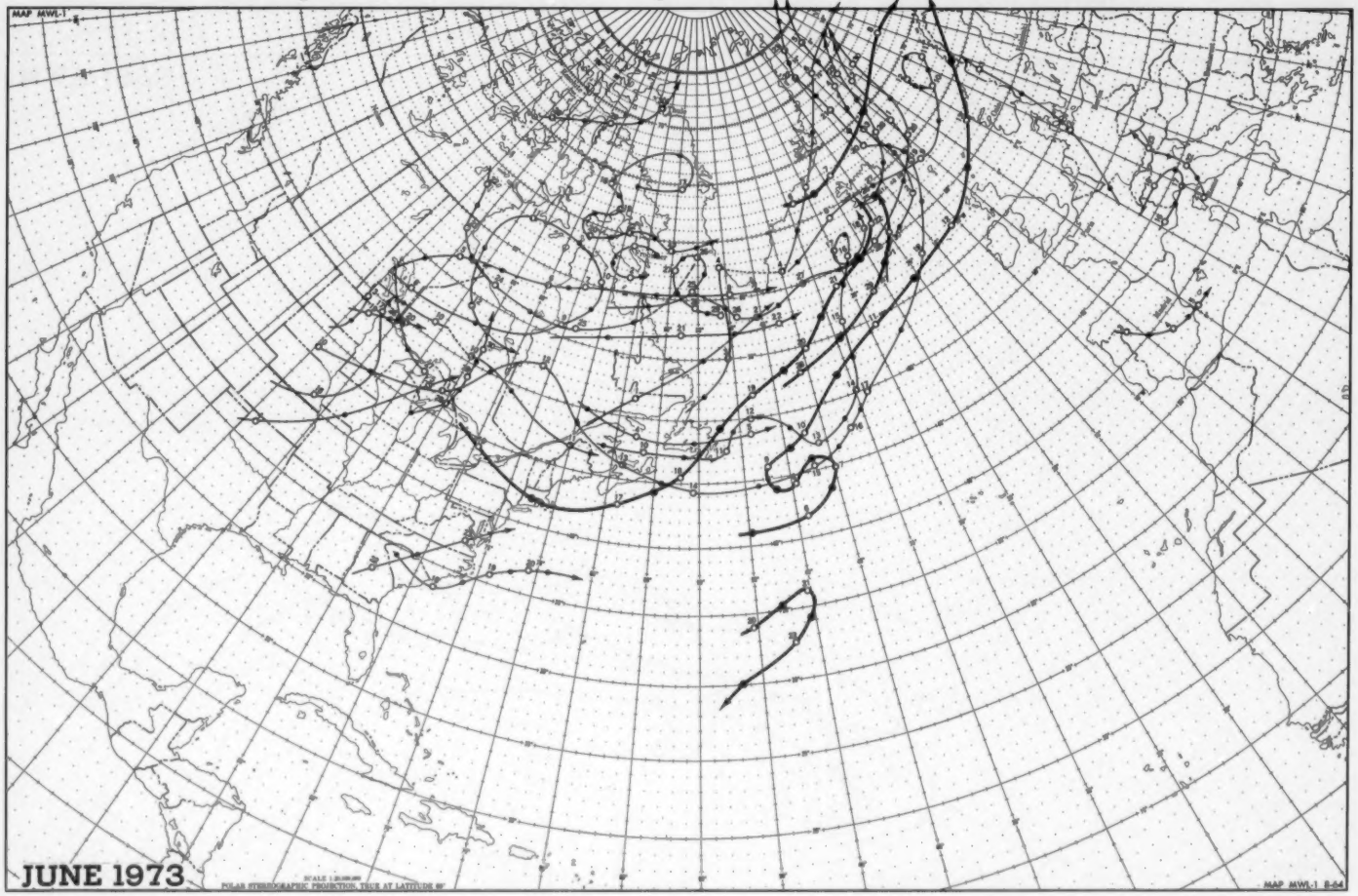

Figure 33.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

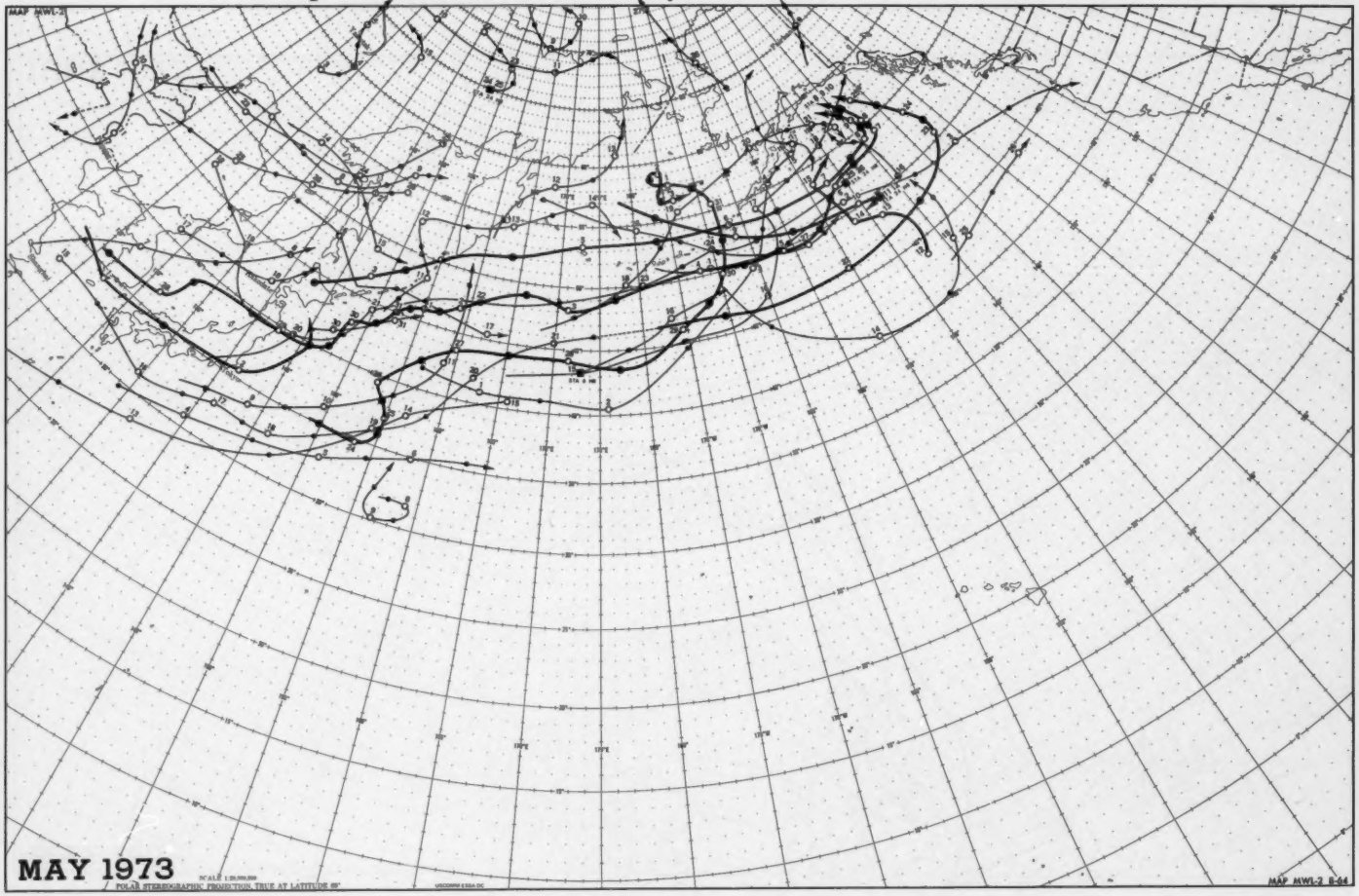

Figure 34.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

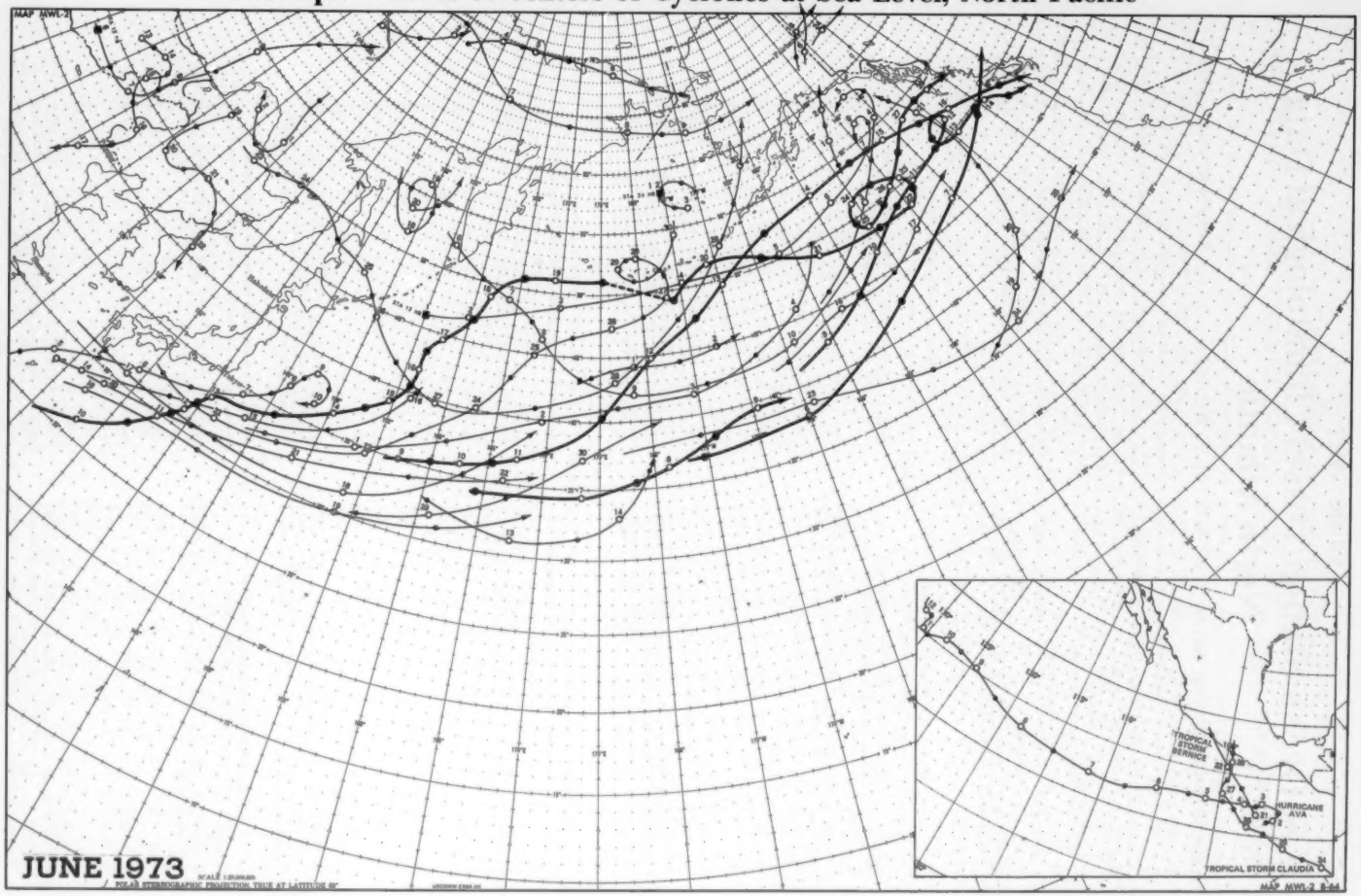

Figure 35.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Table 4

U.S. Ocean Station Vessel Climatological Data, North Atlantic

Ocean Weather Station 'BRAVO' 56°30'N 51°00'W **May and June, 1973**

MEANS AND EXTREMES

MONTH	DRY BULB TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	DEW-POINT TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	SEA TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	AIR-SEA TEMP DIFFERENCE (°C) MIN	DA HR	MEAN	MAX	DA HR
MAY	- .8	07 06	3.5	6.8	23 06	- 8.2	07 09	.6	5.5	11 15	3.0	12 09	4.5	5.7	29 09	- 5.3	07 06	- 1.0	1.8	22 15
JUNE	2.8	*16 09	8.3	9.0	29 18	- 2.8	16 12	3.2	8.0	23 21	2.7	09 09	5.4	8.3	29 18	- 3.5	23 18	- .1	2.9	09 12

MONTH	MEANS AND EXTREMES PRESSURE (MB) MIN	DA HR	MEAN	MAX	DA HR	PERCENTAGE FREQUENCY OF CLOUD AMOUNT (OKTAS) TOTAL CLOUD 0-2	3-5	6-7	S & OBSC	LOW CLOUD 0-2	3-5	6-7	S & OBSC	DAYS WITH SPECIFIED WEATHER RAIN OR SNOW PCPN	DRZL	SNOW	TSTM	VSBY <1KM **	WIND (KTS) ≥34	≥48	≥64	COMP OB DAYS	%OBS WITH PCPN	NO OF OBS
MAY	997.7	*30 12	1019.6	1035.2	*08 12	2.4	7.8	21.6	68.2	9.4	13.1	21.6	55.9	18	17	5	0	3	0	0	0	29	13.9	245
JUNE	983.7	03 21	1011.6	1022.9	24 12	6.3	9.0	23.4	61.2	26.9	10.9	17.4	44.8	12	12	0	0	6	1	0	0	23	12.9	201

** VV-00-03 AND/OR W=4 COMP OB DAYS=COMPLETE OB DAYS

Wind

MAY WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	23-33	34-47	>47	TOTAL	MEAN SPEED
N	.0	0.6	5.1	.7	.0	.0	12.4	11.7
NE	.0	1.0	1.2	.4	.0	.0	2.7	14.2
E	.4	0.9	1.1	.0	.0	.0	6.5	7.7
SE	.0	0.8	4.9	9.9	.0	.0	15.5	14.6
S	1.6	7.9	7.0	3.3	.0	.0	20.2	13.3
SW	1.0	0.7	6.6	.0	.0	.0	14.6	11.3
W	.0	0.4	6.6	.6	.0	.0	13.7	11.3
NW	.4	3.3	9.6	1.1	.0	.0	10.4	12.0
CALM	2.0	.0	.0	.0	.0	.0	2.0	.0
TOTAL	5.7	45.7	38.4	10.2	.0	.0	100.0	12.0

NUMBER OF OBS 245 | MAX WIND DIR 150 | SPEED 33 | DA HR *30 0000 | VECTOR SPEED 9.0 | MEAN DIR 201 | (DIR IN DEGREES)

JUNE WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.0	1.7	3.9	.9	.0	.0	6.5	13.8
NE	.0	2.1	1.9	.5	.0	.0	4.1	12.6
E	.0	5.5	10.7	2.9	.0	.0	19.0	13.3
SE	.0	4.0	3.7	.1	.0	.0	7.8	11.7
S	.0	3.7	4.7	3.6	.0	.0	12.1	13.8
SW	.7	3.2	13.6	1.4	.0	.0	18.9	14.5
W	1.2	3.7	4.2	2.4	.0	.0	11.6	14.7
NW	.9	5.8	6.0	2.7	.5	.0	15.8	15.7
CALM	1.5	.0	.0	.0	.0	.0	1.5	.0
TOTAL	4.0	32.8	48.3	14.4	.5	.0	100.0	14.3

NUMBER OF OBS 201 | MAX WIND DIR 330 | SPEED 38 | DA HR 28 1600 | VECTOR SPEED 2.0 | MEAN DIR 228 | (DIR IN DEGREES)

Wave

MAY WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	1.8	10.6	1.1	.0	.0	.0	.0	.0	13.6
NE	.2	1.6	.8	.0	.0	.0	.0	.0	2.7
E	3.2	9.0	.0	.0	.0	.0	.0	.0	12.1
SE	0.1	13.8	2.4	9.6	.0	.0	.0	.0	25.9
S	4.1	6.3	3.6	2.1	.0	.0	.0	.0	16.3
SW	1.0	5.4	3.1	.0	.0	.0	.0	.0	9.5
W	2.8	2.1	1.4	.0	.0	.0	.0	.0	6.3
NW	3.0	4.8	1.0	.0	.0	.0	.0	.0	8.9
IND	.0	3.7	.0	.0	.0	.0	.0	.0	3.7
CALM	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	21.2	59.5	13.5	9.7	.0	.0	.0	.0	100.0

NUMBER OF OBS 249 IND=INDETERMINATE

JUNE WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	2.0	3.0	1.4	.9	.0	.2	.0	.0	7.5
NE	.5	4.0	2.0	3.1	1.0	.0	.0	.0	10.6
E	.9	6.1	2.9	3.7	2.0	.0	.0	.0	15.5
SE	4.5	3.9	.4	.6	1.0	.0	.0	.0	10.3
S	3.4	8.0	3.1	1.0	.0	.0	.0	.0	15.4
SW	.1	10.7	1.4	1.3	.0	.0	.9	.0	13.7
W	.0	3.5	2.0	.5	.0	.0	.0	.0	9.0
NW	2.0	9.2	3.1	2.6	.5	.0	.0	.0	17.4
IND	.5	.5	1.9	3.0	.0	.0	.0	.0	5.0
CALM	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	13.4	47.8	17.4	16.9	4.5	.0	.0	.0	100.0

NUMBER OF OBS 201 IND=INDETERMINATE

MAY WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	14.3	28.9	3.7	.0	.0	.0	.0	.0	46.9
6-7	3.3	19.6	7.3	9.7	.0	.0	.0	.0	38.0
8-9	1.6	9.4	2.4	.0	.0	.0	.0	.0	13.5
10-11	.0	.0	.0	.0	.0	.0	.0	.0	.0
12-13	.0	.0	.0	.0	.0	.0	.0	.0	.0
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	.0	3.7	.0	.0	.0	.0	.0	.0	3.7
TOTAL	21.2	59.6	13.5	9.7	.0	.0	.0	.0	100.0

NUMBER OF OBS 245 | MAX WAVE HEIGHT HGT 3.5 | PER 6 | DIR 160 | TYPE SEA | DA HR 29 15 | IND=INDETERMINATE (DIR IN DEGREES)

JUNE WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	10.0	31.8	1.0	.5	.0	.0	.0	.0	43.3
6-7	2.5	10.4	13.9	9.0	1.0	.0	.0	.0	36.8
8-9	.5	4.0	1.5	3.5	3.0	.0	.0	.0	12.4
10-11	.0	.5	.0	1.0	.5	.0	.0	.0	2.0
12-13	.0	.5	.0	.0	.0	.0	.0	.0	.5
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	.5	.5	1.0	3.0	.0	.0	.0	.0	5.0
TOTAL	13.4	47.8	17.4	16.9	4.5	.0	.0	.0	100.0

NUMBER OF OBS 201 | MAX WAVE HEIGHT HGT 4.8 | PER 9 | DIR 120 | TYPE SWL | DA HR 13 00 | IND=INDETERMINATE (DIR IN DEGREES)

*ALSO OCCURRED ON PREVIOUS OBSERVATIONS

For each observation, the higher wave of the sea/swell group was selected for summarization; if heights were equal, the wave with the longer period was selected; if periods were also equal, the sea wave was used.

Table 5
CLIMATOLOGICAL DATA

Ocean Weather Station 'CHARLIE' 52°45'N 35°30'W — May and June, 1973

MEANS AND EXTREMES

MONTH	DRY BULB TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	DEW-POINT TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	SEA TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	AIR-SEA TEMP DIFFERENCE (°C) MIN	DA HR	MEAN	MAX	DA HR
MAY	4.0	04 03	7.6	10.3	26 18	- 2.0	09 00	4.9	10.1	14 18	8.1	•18 12	8.4	13.9	•19 15	- 7.7	19 12	- .9	2.9	14 21
JUNE	6.7	18 03	9.3	12.2	09 15	1.1	•17 12	7.1	11.2	11 03	8.7	•05 12	10.4	14.4	10 00	- 4.4	22 03	- 1.1	1.7	03 19

MONTH	PRESSURE (MB) MIN	DA HR	MEAN	MAX	DA HR	PERCENTAGE FREQUENCY OF CLOUD AMOUNT (OKTAS) TOTAL CLOUD 0-2	3-5	6-7	8 & OBSC	LOW CLOUD 0-2	3-5	6-7	8 & OBSC	DAYS WITH SPECIFIED WEATHER RAIN OR PCPN	DRZL	SNOW	TSTM	VERY <1KM **	WIND (KTS) ≥34	≥48	≥64	COMP OB DAYS	%OBS WITH PCPN	NO OF OBS
MAY	1002.0	04 18	1018.8	1034.1	09 18	2.1	8.1	21.7	68.1	9.4	21.3	29.4	44.0	20	20	0	0	3	3	0	0	26	17.9	239
JUNE	990.5	14 18	1013.0	1029.8	25 00	6.8	4.2	10.5	72.6	20.3	10.1	13.6	54.0	22	22	0	0	13	7	0	0	26	19.0	237

** VV-90-93 AND/OR V=4 COMP OB DAYS=COMPLETE OB DAYS

Wind

MAY — WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.0	7.3	9.4	2.8	.0	.0	19.5	14.9
NE	.0	4.7	12.3	5.4	.9	.0	23.3	17.8
E	.4	3.1	5.1	.3	.0	.0	8.9	12.7
SE	.4	4.1	5.2	.9	.0	.0	10.7	12.2
S	.4	1.5	2.3	2.3	.4	.0	6.9	17.4
SW	.5	1.4	3.6	2.4	.0	.0	8.2	16.6
W	.3	2.3	6.4	1.6	.0	.0	10.6	14.6
NW	.4	4.9	5.2	.4	.0	.0	11.0	11.4
CALM	.9	.0	.0	.0	.0	.0	.9	.0
TOTAL	3.4	29.4	49.8	16.2	1.3	.0	100.0	14.7

NUMBER OF OBS 235 — MAX WIND DIR 210, SPEED 36, DA HR 14 1700 — VECTOR SPEED 9.9 — MEAN DIR 024 — (DIR IN DEGREES)

JUNE — WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.4	3.5	2.3	.0	.0	.0	6.2	9.9
NE	.0	.5	1.8	.4	.4	.0	3.2	17.7
E	.0	.7	.9	1.3	3.8	.0	6.6	21.2
SE	.8	1.9	.9	.8	.8	.0	5.4	14.7
S	.4	6.0	5.6	1.5	.0	.0	13.5	12.9
SW	.0	5.8	8.9	4.6	.4	.0	19.7	16.1
W	.8	4.9	8.9	4.1	1.8	.0	20.5	17.9
NW	.0	4.5	9.2	6.6	.7	.0	21.1	18.4
CALM	3.8	.0	.0	.0	.0	.0	3.8	.0
TOTAL	6.3	27.8	38.4	19.4	8.0	.0	100.0	16.6

NUMBER OF OBS 237 — MAX WIND DIR 080, SPEED 46, DA HR 19 0100 — VECTOR SPEED 5.8 — MEAN DIR 265 — (DIR IN DEGREES)

Wave

MAY — WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	.0	7.1	12.3	.9	.0	.0	.0	.0	20.3
NE	.0	13.5	8.2	1.8	2.1	.0	.0	.0	27.7
E	.0	2.0	3.2	.7	.0	.0	.0	.0	6.0
SE	.0	4.5	2.3	.0	.0	.0	.0	.0	7.1
S	.0	3.2	2.4	.4	.0	.0	.0	.0	6.1
SW	.0	3.0	4.0	.0	.0	.0	.0	.0	7.0
W	.0	1.7	4.9	.0	.0	.0	.0	.0	6.6
NW	.0	2.7	2.6	.0	.0	.0	.0	.0	5.2
IND	.0	8.1	6.0	.0	.0	.0	.0	.0	14.0
CALM	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	.0	48.1	46.0	3.8	2.1	.0	.0	.0	100.0

NUMBER OF OBS 235 — IND=INDETERMINATE

JUNE — WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	.0	4.1	.3	.0	.0	.0	.0	.0	4.4
NE	.0	.2	.0	1.3	1.3	.0	.0	.0	3.0
E	.0	.8	.8	1.5	3.4	.0	.0	.0	6.5
SE	.8	1.1	.4	.4	.0	.0	.0	.0	3.0
S	.0	6.3	1.4	.4	.0	.0	.0	.0	8.1
SW	.9	4.0	7.7	2.2	.0	.0	.0	.0	14.9
W	.3	15.3	9.5	4.0	2.0	.0	.0	.0	30.2
NW	.0	6.8	8.2	4.3	1.4	.0	.0	.0	20.7
IND	.0	6.8	.8	1.7	.0	.0	.0	.0	9.3
CALM	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	1.3	46.4	28.3	16.0	8.0	.0	.0	.0	100.0

NUMBER OF OBS 237 — IND=INDETERMINATE

MAY — WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	.0	25.5	12.8	.0	.0	.0	.0	.0	38.3
6-7	.0	13.6	20.4	2.1	2.1	.0	.0	.0	38.3
8-9	.0	.9	6.8	.9	.0	.0	.0	.0	8.5
10-11	.0	.0	.0	.0	.0	.0	.0	.0	.0
12-13	.0	.0	.0	.4	.0	.0	.0	.0	.4
>13	.0	.0	.0	.4	.0	.0	.0	.0	.4
IND	.0	8.1	6.0	.0	.0	.0	.0	.0	14.0
TOTAL	.0	48.1	46.0	3.8	2.1	.0	.0	.0	100.0

NUMBER OF OBS 235 — MAX WAVE HEIGHT HGT 4.5, PER 7, DIR 050, TYPE SEA, DA HR 27 18 — IND=INDETERMINATE (DIR IN DEGREES)

ALSO OCCURRED ON PREVIOUS OBSERVATION

JUNE — WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	1.3	21.1	14.3	1.3	.0	.0	.0	.0	38.0
6-7	.0	13.5	11.4	9.7	3.4	.0	.0	.0	38.0
8-9	.0	3.8	1.7	3.4	4.6	.0	.0	.0	13.5
10-11	.0	.8	.0	.0	.0	.0	.0	.0	.8
12-13	.0	.4	.0	.0	.0	.0	.0	.0	.4
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	.0	6.8	.8	1.7	.0	.0	.0	.0	9.3
TOTAL	1.3	46.4	28.3	16.0	8.0	.0	.0	.0	100.0

NUMBER OF OBS 237 — MAX WAVE HEIGHT HGT 5.9, PER 8, DIR 080, TYPE SEA, DA HR 19 09 — IND=INDETERMINATE (DIR IN DEGREES)

For each observation, the higher wave of the sea/swell group was selected for summarization; if heights were equal, the wave with the longer period was selected; if periods were also equal, the sea wave was used.

Table 6
CLIMATOLOGICAL DATA

Ocean Weather Station 'DELTA' 44°00'N 41°00'W — May and June, 1973

MEANS AND EXTREMES

MONTH	DRY BULB TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	DEW-POINT TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	SEA TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	AIR-SEA TEMP DIFFERENCE (°C) MIN	DA HR	MEAN	MAX	DA HR
MAY	10.7	18 06	14.3	17.9	09 12	5.7	21 03	10.7	16.2	09 12	14.4	e30 21	15.4	21.7	11 21	- 6.1	11 21	- 1.1	1.8	14 18
JUNE	12.9	08 00	16.5	20.8	25 18	5.0	05 09	13.6	18.0	29 18	14.7	01 06	17.6	20.6	e29 00	- 4.8	13 09	- 1.2	2.3	18 18

MEANS AND EXTREMES — PRESSURE (MB)

MONTH	MIN	DA HR	MEAN	MAX	DA HR
MAY	1002.9	26 19	1018.9	1037.9	14 00
JUNE	996.0	13 06	1020.0	1034.6	25 12

PERCENTAGE FREQUENCY OF CLOUD AMOUNT (OKTAS)

MONTH	TOTAL CLOUD 0-2	3-5	6-7	8 & OBSC	LOW CLOUD 0-2	3-5	6-7	8 & OBSC
MAY	18.2	21.4	34.9	25.5	16	16	0	0
JUNE	20.4	28.0	22.9	28.2	21	21	0	1

DAYS WITH SPECIFIED WEATHER

MONTH	RAIN OR DRZL	SNOW	TSTM	VSBY <1KM **	WIND (KTS) ≥34	≥48	≥64	COMP OB DAYS	%OBS WITH PCPN	NO OF OBS
MAY	16	16	0	0	1	5	0	0	21	15.1	192
JUNE	21	21	0	1	5	8	0	0	28	19.8	242

** VV-90-93 AND/OR W-4 — COMP OB DAYS-COMPLETE OB DAYS

Wind

MAY — WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.0	2.2	9.5	1.0	.0	.0	6.8	13.0
NE	.5	4.4	9.6	4.2	.0	.0	18.8	13.8
E	.0	1.0	2.0	.0	.0	.0	3.0	13.3
SE	.0	1.4	2.9	3.1	.5	.0	7.9	19.5
S	.0	4.4	6.8	.9	.0	.0	12.1	13.6
SW	.0	.5	5.6	8.3	.7	.0	15.1	22.7
W	.0	1.4	3.6	11.6	2.9	.0	19.5	24.6
NW	.0	1.7	6.1	5.7	.7	.0	14.2	20.5
CALM	2.6	.0	.0	.0	.0	.0	2.6	.0
TOTAL	3.1	17.2	40.1	34.9	4.7	.0	100.0	18.9

NUMBER OF OBS	MAX WIND DIR	SPEED	DA HR	VECTOR SPEED	MEAN DIR	(DIR IN DEGREES)
192	280	45	18 0300	8.2	274	

JUNE — WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.0	2.9	1.1	.0	2.0	.0	6.0	19.3
NE	.0	1.4	.0	.8	.0	.0	2.3	16.7
E	.0	.8	.3	.3	.0	.0	1.4	11.6
SE	.0	3.0	1.3	.3	.0	.0	4.6	9.7
S	.0	.7	3.7	6.7	1.0	.0	14.2	21.7
SW	.0	2.1	12.0	7.7	1.1	.0	22.9	19.8
W	.0	9.5	9.0	9.8	2.3	.0	30.6	17.8
NW	.0	4.3	8.2	3.6	1.0	.0	17.1	17.6
CALM	.8	.0	.0	.0	.0	.0	.8	.0
TOTAL	.8	24.8	37.6	29.3	7.4	.0	100.0	18.3

NUMBER OF OBS	MAX WIND DIR	SPEED	DA HR	VECTOR SPEED	MEAN DIR	(DIR IN DEGREES)
242	250	49	17 0400	10.9	234	

Wave

MAY — WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	.0	5.4	3.7	.5	.0	.0	.0	.0	9.6
NE	.0	6.2	15.2	.5	.0	.0	.0	.0	21.9
E	1.0	.9	.9	.0	.0	.0	.0	.0	2.9
SE	.0	2.1	3.7	.5	.0	.0	.0	.0	6.3
S	.5	3.8	1.4	.5	.4	.0	.0	.0	8.9
SW	.4	2.7	7.5	4.3	1.8	.0	.0	.0	16.8
W	.4	3.8	8.4	2.4	3.4	.0	.0	.0	18.3
NW	.5	3.5	3.8	2.7	.7	.0	.0	.0	11.3
IND	.0	3.7	.5	.0	.0	.0	.0	.0	4.2
CALM	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	3.1	34.0	45.0	11.5	6.3	.0	.0	.0	100.0

NUMBER OF OBS 191 — IND=INDETERMINATE

JUNE — WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	.3	.4	.0	.8	1.1	.0	.0	.0	2.7
NE	.0	.4	.8	.0	.0	.0	.0	.0	1.2
E	.0	.4	.0	.0	.0	.0	.0	.0	.4
SE	.1	1.1	.1	.0	.0	.0	.0	.0	1.3
S	.3	4.9	3.3	.4	.0	.0	.0	.0	10.8
SW	.0	8.7	7.0	4.0	.1	.0	.0	.0	19.8
W	.7	9.8	7.4	4.9	1.8	.0	.0	.0	23.6
NW	1.4	8.6	5.0	2.3	1.5	.0	.0	.0	18.8
IND	1.7	10.5	2.3	.0	.0	.0	.0	.0	20.7
CALM	.4	.0	.0	.0	.0	.0	.0	.0	.4
TOTAL	5.0	50.0	28.1	12.4	4.5	.0	.0	.0	100.0

NUMBER OF OBS 242 — IND=INDETERMINATE

MAY — WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	1.6	19.2	13.9	1.6	.0	.0	.0	.0	31.9
6-7	.5	11.5	29.1	9.4	5.2	.0	.0	.0	51.8
8-9	.0	3.7	3.1	.5	1.0	.0	.0	.0	8.4
10-11	.0	.0	2.6	.0	.0	.0	.0	.0	2.6
12-13	.0	.0	.0	.0	.0	.0	.0	.0	.0
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	1.0	3.7	.5	.0	.0	.0	.0	.0	5.2
TOTAL	3.1	34.0	45.0	11.5	6.3	.0	.0	.0	100.0

NUMBER OF OBS	MAX WAVE HEIGHT HGT	PER	DIR	TYPE	DA HR	IND=INDETERMINATE
191	5.9	8	280	SEA	26 18	(DIR IN DEGREES)

JUNE — WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	3.3	23.6	5.8	.0	.0	.0	.0	.0	34.7
6-7	.0	4.1	18.6	2.1	.8	.0	.0	.0	25.6
8-9	.0	2.9	1.2	10.3	1.7	.0	.0	.0	16.1
10-11	.0	.8	.0	.0	2.1	.0	.0	.0	2.9
12-13	.0	.0	.0	.0	.0	.0	.0	.0	.0
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	1.7	18.5	2.3	.0	.0	.0	.0	.0	20.7
TOTAL	5.0	50.0	28.1	12.4	4.5	.0	.0	.0	100.0

NUMBER OF OBS	MAX WAVE HEIGHT HGT	PER	DIR	TYPE	DA HR	IND=INDETERMINATE
242	4.9	8	240	SEA	07 09	(DIR IN DEGREES)

*ALSO OCCURRED ON PREVIOUS OBSERVATIONS

For each observation, the higher wave of the sea/swell group was selected for summarization; if heights were equal, the wave with the longer period was selected; if periods were also equal, the sea wave was used.

Table 7
CLIMATOLOGICAL DATA

Ocean Weather Station 'ECHO' 35°00'N 48°00'W — May and June, 1973

MEANS AND EXTREMES

MONTH	DRY BULB TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	DEW-POINT TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	SEA TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	AIR-SEA TEMP DIFFERENCE (°C) MIN	DA HR	MEAN	MAX	DA HR
MAY	16.7	03 12	19.7	24.0	23 15	8.9	02 12	16.5	20.4	31 15	17.7	03 12	19.9	21.8	24 09	-3.0	21 03	-.2	4.2	06 18
JUNE	17.5	10 09	21.5	23.6	23 12	9.2	09 09	18.0	21.8	06 15	20.6	13 06	21.4	22.8	24 18	-4.1	10 09	.0	2.2	15 18

MONTH	MEANS AND EXTREMES PRESSURE (MB) MIN	DA HR	MEAN	MAX	DA HR	PERCENTAGE FREQUENCY OF CLOUD AMOUNT (OKTAS) TOTAL CLOUD 0-2	3-5	6-7	8 & OBSC	LOW CLOUD 0-2	3-5	6-7	8 & OBSC	DAYS WITH SPECIFIED WEATHER RAIN OR DRZL PCPN	SNOW	TSTM	VSBY <1KM **	WIND (KTS) ≥34	≥48	≥64	COMP OB DAYS	%OBS WITH PCPN	NO OF OBS
MAY	1008.9	21 09	1022.0	1032.9	15 15	19.6	28.2	33.9	18.4	41.6	38.7	16.3	3.3	16	16	0	0	0	0	0	29	9.5	249
JUNE	1015.1	13 06	1029.6	1030.5	27 12	25.0	21.4	37.0	16.7	50.0	24.5	18.2	7.3	10	10	0	0	2	0	0	21	9.3	192

** VV-90-93 AND/OR W=4 COMP OB DAYS=COMPLETE OB DAYS

Wind

MAY — WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.0	4.1	5.4	.9	.0	.0	9.8	12.8
NE	.0	.6	1.7	.1	.0	.0	2.4	12.1
E	.3	.4	.7	.0	.0	.0	1.4	8.5
SE	.9	4.6	2.9	.0	.0	.0	7.4	9.1
S	.4	10.2	9.1	1.0	.0	.0	20.7	9.7
SW	1.2	9.9	12.4	.6	.0	.0	24.2	11.4
W	.4	7.1	4.6	.0	.0	.0	12.1	10.2
NW	.0	7.7	4.1	.0	.0	.0	11.7	9.6
CALM	4.1	.0	.0	.0	.0	.0	4.1	.0
TOTAL	6.9	50.6	40.4	2.0	.0	.0	100.0	10.2

NUMBER OF OBS 245 — MAX WIND SPEED 28, DA HR 28 1600 — VECTOR SPEED 4.3, MEAN DIR 230 (DIR IN DEGREES)

JUNE — WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.0	1.3	2.0	.4	.0	.0	3.6	13.0
NE	.5	5.5	4.6	.7	.0	.0	11.2	11.3
E	.5	4.4	24.7	1.0	.0	.0	30.7	14.2
SE	.0	2.7	2.5	.0	.0	.0	5.2	11.2
S	.5	2.2	4.3	3.6	.0	.0	10.7	16.1
SW	.5	6.4	12.5	3.9	.0	.0	23.3	15.7
W	.0	2.0	9.2	.8	.0	.0	12.0	16.1
NW	.0	1.0	.1	.0	.0	.0	1.2	7.7
CALM	2.1	.0	.0	.0	.0	.0	2.1	.0
TOTAL	4.2	25.5	59.9	10.4	.0	.0	100.0	14.2

NUMBER OF OBS 192 — MAX WIND SPEED 33, DA HR 16 1530 — VECTOR SPEED 3.4, MEAN DIR 161 (DIR IN DEGREES)

Wave

MAY — WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	.0	3.3	2.3	.0	.0	.0	.0	.0	5.6
NE	.0	5.3	3.0	.0	.0	.0	.0	.0	8.3
E	.3	2.9	.3	.0	.0	.0	.0	.0	3.5
SE	2.4	1.1	.0	.0	.0	.0	.0	.0	3.6
S	10.8	6.9	3.6	.0	.0	.0	.0	.0	21.3
SW	3.0	9.5	4.0	.0	.0	.0	.0	.0	16.4
W	3.1	7.7	8.8	.0	.0	.0	.0	.0	19.5
NW	.8	10.3	1.7	.0	.0	.0	.0	.0	12.9
IND	.0	3.7	3.7	.0	.0	.0	.0	.0	7.3
CALM	1.6	.0	.0	.0	.0	.0	.0	.0	1.6
TOTAL	22.0	50.6	27.3	.0	.0	.0	.0	.0	100.0

NUMBER OF OBS 245 — IND=INDETERMINATE

JUNE — WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	.8	11.3	1.0	.0	.0	.0	.0	.0	13.2
NE	.1	3.3	.7	.0	.0	.0	.0	.0	4.0
E	1.4	24.1	3.0	.0	.0	.0	.0	.0	28.3
SE	.0	7.2	.0	.0	.0	.0	.0	.0	7.2
S	.0	10.8	3.1	.0	.0	.0	.0	.0	13.9
SW	.0	6.6	3.5	2.6	.0	.0	.0	.0	12.8
W	1.6	3.6	11.6	1.0	.0	.0	.0	.0	17.8
NW	.3	1.8	.5	.0	.0	.0	.0	.0	2.6
IND	.0	.0	.0	.0	.0	.0	.0	.0	.0
CALM	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	4.2	68.8	23.4	3.6	.0	.0	.0	.0	100.0

NUMBER OF OBS 192 — IND=INDETERMINATE

MAY — WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	22.0	18.4	9.7	.0	.0	.0	.0	.0	40.1
6-7	.0	17.1	9.0	.0	.0	.0	.0	.0	26.1
8-9	.0	10.2	8.2	.0	.0	.0	.0	.0	18.4
10-11	.0	.4	.8	.0	.0	.0	.0	.0	1.2
12-13	.0	.4	.0	.0	.0	.0	.0	.0	.4
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	.0	4.1	3.7	.0	.0	.0	.0	.0	7.8
TOTAL	22.0	50.6	27.3	.0	.0	.0	.0	.0	100.0

NUMBER OF OBS 245 — MAX WAVE HEIGHT: HGT 2.5, PER 8, DIR 270, TYPE SWL, DA HR 03 15 (DIR IN DEGREES) — IND=INDETERMINATE

*ALSO OCCURRED ON PREVIOUS OBSERVATIONS

JUNE — WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	2.6	40.1	3.6	.0	.0	.0	.0	.0	46.4
6-7	1.0	24.0	18.8	2.6	.0	.0	.0	.0	46.4
8-9	.5	4.7	.5	1.0	.0	.0	.0	.0	6.8
10-11	.0	.0	.5	.0	.0	.0	.0	.0	.5
12-13	.0	.0	.0	.0	.0	.0	.0	.0	.0
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	4.2	68.8	23.4	3.6	.0	.0	.0	.0	100.0

NUMBER OF OBS 192 — MAX WAVE HEIGHT: HGT 3.5, PER 8, DIR 220, TYPE SEA, DA HR 16 15 (DIR IN DEGREES) — IND=INDETERMINATE

For each observation, the higher wave of the sea/swell group was selected for summarization; if heights were equal, the wave with the longer period was selected; if periods were also equal, the sea wave was used.

Table 8

Selected Gale Observations, North Atlantic

May and June 1973

Vessel	Nationality	Date	Position of Ship Lat. deg.	Position of Ship Long. deg.	Time GMT	Wind Dir. 10's	Wind Speed kt	Visibility	Present Weather code	Pressure mb	Temperature °C Air	Temperature °C Sea	Sea Waves Period sec	Sea Waves Height ft	Swell Waves Dir. 10's	Swell Waves Period sec	Swell Waves Height ft
NORTH ATLANTIC		MAY															
MV VEMA R/V	PANAMANIAN	1	35.2 N	34.2 W	00	32	35	5 NM	02	1008.0	18.0	17.5	8	11.5			
SS MT MITCHELL	AMERICAN	1	40.0 N	26.1 W	06	03	M 36	2 NM	05	1003.0	12.0	14.5	5	6.5	04	7	11.5
MV BOE SOTTORF	GERMAN	1	38.0 N	20.2 W	12	24	37	10 NM	02	997.6	17.1		7	13			
SS AMER ACCORD	AMERICAN	3	49.2 N	16.0 W	18	34	37	5 NM	25	997.0	11.0	12.2					
SS TILLIE LYKES	AMERICAN	3	48.5 N	13.6 W	00	02	M 45	5 NM	02	991.5	12.7	12.2	XX	14.5			
SS T L LENZEN	LIBERIAN	3	24.6 N	63.8 W	12	34	35	10 NM	03	1016.5	22.8	25.6	4	13			
SS AMER ACCORD	AMERICAN	4	49.9 N	14.1 W	00	36	40	5 Nm	20	990.0	10.0	12.2	14	24.5			
SS ORE CHIEF	LIBERIAN	4	46.3 N	09.5 W	12	24	42	5 NM	02	1004.7	13.2	17.3	6	10			
SS SEALAND COMMERCE	AMERICAN	4	47.2 N	16.7 W	12	29	36	10 NM	01	1010.5	11.2	10.0	9	11.5			
SS AMER LEGEND	AMERICAN	6	49.1 N	18.3 W	12	32	35	10 NM	03	1016.6	13.0	11.5	5	13			
USNS NORWALK T AK 279	AMERICAN	6	46.6 N	19.9 W	00	27	M 33	5 NM	02	1013.8	12.8	13.1	5	11.5			
USCGC MORGENTHAU	AMERICAN	7	42.3 N	66.2 W	21	34	M 35	10 NM	02	1021.4	5.9	6.1	6	6.5			
USCGC MORGENTHAU	AMERICAN	8	43.8 N	64.1 W	06	34	M 39	5 NM	21	1019.0	2.9	3.3	6	6.5			
SS AFRICAN STAR	AMERICAN	8	18.7 N	20.7 W	12	02	35	10 NM	02	1013.2	21.1	20.0	8	8			
MV M P GRACE	LIBERIAN	9	57.5 N	17.9 W	12	29	40	5 NM	03	1010.0	8.9	10.6	5	14.5			
SS PORTLAND	AMERICAN	10	35.4 N	71.7 W	06	18	35	5 NM	18	1014.0	20.0	25.0	3	16.5			
MV M P GRACE	LIBERIAN	10	58.5 N	10.7 W	06	30	40	10 NM		1001.9	8.9	9.7	12	16.5			
USCGC MORGENTHAU	AMERICAN	11	42.9 N	48.1 W	00	28	M 36	2 NM	31	1014.4	9.4	13.9	5	5			
SS AMER ACCORD	AMERICAN	11	42.0 N	52.7 W	12	27	35	5 NM	62	1004.0	13.6	17.2	9	14.5			
SS RIO HANAMO	LIBERIAN	11	55.0 N	15.0 W	06	27	35	10 NM	03	1018.6	9.3	10.0	5	11.5			
SS RIO HANAMO	LIBERIAN	14	47.8 N	40.3 W	12	20	38	2 NM	30	1012.5	15.7	15.7	4	8			
MV TOYOTA MARU #12	JAPANESE	17	37.9 N	62.3 W	18	19	M 38	2 NM	28	1012.0	22.0	23.0	8	14.5			
USCGC DUANE	AMERICAN	18	49.4 N	43.9 W	00	31	38	5 NM	02	1007.5	6.5	8.0	7	11.5			
MV SKAUBORG	NORWEGIAN	18	40.7 N	29.1 W	18	29	38	5 NM	58	1006.5	16.0	14.0	10	10			
MV NIRPAK	AMERICAN	18	43.6 N	36.0 W	06	29	M 38	5 NM	03	1009.1	17.7	17.0	10	14.5			
MV SKAUBORG	NORWEGIAN	19	40.7 N	27.5 W	00	29	48	10 NM	91	1004.0	16.0	15.0	12	11.5			
SS SEALAND TRADER	AMERICAN	19	44.1 N	27.3 W	18	32	35	5 NM	02	1006.4	12.5	12.4		11.5			
SS SEALAND TRADER	AMERICAN	20	42.8 N	31.2 W	00	32	40	5 NM	02	1009.8	13.4	12.2	5				
SS SEALAND ECONOMY	AMERICAN	20	43.8 N	27.5 W	06	31	M 36	10 NM	18	1002.3	12.8	14.4	12	10			
SS EXPORT AGENT	AMERICAN	21	38.6 N	13.3 W	18	27	35	10 NM	01	1000.3	15.0	18.7	3	5	23	< 6	13
SS JR GREY	LIBERIAN	21	31.9 N	48.2 W	06	18	M 35	10 NM	02	1015.0	20.0	23.5					
SS ESSO FLORENCE	AMERICAN	23	32.8 N	73.7 W	12	23	M 40	10 NM	01	1006.4	25.0	28.3	8	10			
SS EXPORT AGENT	AMERICAN	26	39.1 N	48.8 W	12	28	35	5 NM	02	1010.5	18.8	18.8	4	6.5	25	8	14.5
SS AMER ACCORD	AMERICAN	26	44.0 N	41.3 W	12	18	35	2 NM	80	1005.2	15.6	15.6	7	8	20	9	11.5
SS OCEANIC	PANAMANIAN	26	30.4 N	73.8 W	06	05	35	5 NM	02	1011.5	12.2	13.9	4	8			
SS AMER ACCORD	AMERICAN	27	45.5 N	36.5 W	00	20	35	2 NM	31	1004.5	15.0	14.4	9	13			
SS ESSO FLORENCE	AMERICAN	28	26.9 N	68.0 W	00	18	M 40	5 NM	02	1004.4	26.6	28.3	11	8			
SS NORTHFIELD	AMERICAN	28	23.8 N	85.7 W	18	15	35	10 NM	02	975.3	26.5	28.0	8	6.5			
SS MINNITES	BRITISH	29	11.3 N	73.6 W	18	06	35	5 NM	02	1006.6	30.3	28.9	2	6.5	06	10	26
SS DOCTOR LYKES	AMERICAN	30	46.6 N	19.2 W	18	01	40	10 NM	15	1009.2	14.4	14.0	6	13			
SS SEALAND GALLOWAY	AMERICAN	30	45.7 N	26.2 W	06	30	35	2 NM	80	1007.5	13.4	13.4	5	10			
SS MINNITES	BRITISH	30	11.9 N	74.0 W	06	02	40	5 NM	02	1009.5	27.2	27.8	2	6.5	05	10	32.5
SS ESSO FLORENCE	AMERICAN	30	28.5 N	91.8 W	18	09	M 35	5 NM	05	1021.0	27.0	26.1	2	5			
SS ADM W M CALLAGHAN	AMERICAN	30	37.5 N	12.1 W	12	36	35	5 NM	02	1005.0	7.7	10.3	9	16.5			
SS SEALAND ECONOMY	AMERICAN	31	47.8 N	13.0 W	12	36	M 35	10 NM	02	1014.6	15.6	12.2	2	6.5	36	6	10
SS RIO HANAMO	LIBERIAN	31	36.0 N	73.3 W	06	20	35	10 NM	03	1013.2	24.9	26.7					
SS DOCTOR LYKES	AMERICAN	31	47.4 N	14.4 W	06	01	35	10 NM	80	1013.3	13.2	12.8	3	10	20	9	19.5
OCEAN STATION VESSELS																	
ATLANTIC C																	
USCGC DUANE	AMERICAN	27	32.7 N	35.6 W	15	05	M 35	1 NM	61	1004.2	7.8	9.4	7	13			
USCGC DUANE	AMERICAN	28	32.5 N	35.8 W	12	04	M 35	10 NM	02	1015.7	8.3	9.4	7	13			
ATLANTIC D																	
USCGC MORGENTHAU	AMERICAN	17	44.1 N	40.7 W	21	26	M 35	5 NM	02	1014.7	16.4	15.7	6	11.5			
USCGC MORGENTHAU	AMERICAN	18	44.2 N	40.7 W	03	28	M 45	5 NM	80	1015.8	11.4	15.7	6	13			
USCGC MORGENTHAU	AMERICAN	20	43.4 N	41.0 W	21	26	M 38	5 NM	02	1008.5	13.9	13.3	6	13			
GREAT LAKES VESSELS																	
SS BENJAMIN F FAIRLESS	AMERICAN	1	47.2 N	86.0 W	18	04	38	2 NM	21		2.0	2.0	3	6.5			
SS EDMUND FITZGERALD	AMERICAN	2	48.2 N	87.3 W	18	04	47	.25 NM	94		- 1.0	2.0	5	10			
SS MIDDLETOWN	AMERICAN	2	47.3 N	85.3 W	18	05	M 48	2 NM	61		3.0	2.0	6	11.5			
SS ARTHUR M ANDERSON	AMERICAN	2	47.3 N	87.0 W	18	05	M 41	5 NM	03		2.0	3.0	13	13			
SS ERNEST R BREECH	AMERICAN	2	46.7 N	90.8 W	06	02	M 40	5 NM	03		2.0	1.0					
SS G M HUMPHREY	AMERICAN	2	47.8 N	85.5 W	18	06	M 42	5 NM	61		1.0	2.0	4	8			
SS PAUL H CARNAHAN	AMERICAN	2	47.6 N	88.3 W	00	03	M 39	2 NM	23		- 0.6	2.2	7	8			
SS ARTHUR M ANDERSON	AMERICAN	3	47.9 N	87.8 W	00	02	M 42	2 NM	26		0.0	3.0	12	19.5			
SS JOHN DYKSTRA	AMERICAN	15	47.0 N	91.5 W	18	23	M 35	10 NM	03		13.0	2.0					
SS ERNEST T WEIR	AMERICAN	16	45.2 N	83.2 W	18	31	M 36	5 NM	21		2.0	4.0	4	6.5			
SS ARTHUR M ANDERSON	AMERICAN	16	45.3 N	86.2 W	06	18	M 38	> 25 NM	03		7.0	4.0	12	8			
SS EDMUND FITZGERALD	AMERICAN	28	47.1 N	86.0 W	18	05	38	10 NM	02		5.0	2.0	5	5			
NORTH ATLANTIC		JUNE															
SS SEATRAIN OHIO	AMERICAN	4	13.6 N	72.9 W	12	10	M 40	5 NM	02	1010.5	26.2	25.6	5	8	11	10	13
MV SILVER STONE	LIBERIAN	5	12.0 N	74.0 W	12	07	25	2 NM	81	1011.9	28.0	29.0	7	10			
SS SEATRAIN OHIO	AMERICAN	5	15.0 N	70.7 W	00	10	M 40	5 NM	01	1012.5	26.7	27.3	3	8	11	10	16.5
SS MARSHFIELD	AMERICAN	5	36.6 N	62.5 W	12	24	35	5 NM	15	1017.9	22.8	27.7	3	5	24	11	10
MV WESER	GERMAN	5	36.9 N	36.0 W	18	25	37	10 NM	01	1012.0	10.0	7.1	7	10			
SS SANTA MERCEDES	AMERICAN	6	12.1 N	72.8 W	00	07	38	10 NM	02	1018.3	26.2	27.7	3	6.5	07	6	10
SS ADM W M CALLAGHAN	AMERICAN	6	43.4 N	42.3 W	18	07	35	2 NM	69	1012.0	12.2	17.3	3	5	07	8	11.5
MV WESER	GERMAN	7	33.2 N	50.8 W	06	32	36	5 NM	02	1009.0	6.0	3.0	3	6.5			
MV VEMA R/V	PANAMANIAN	8	36.0 N	36.5 W	06	25	35	5 NM	02	1013.9	8.2	6.8	4	6.5	23	9	14.5
SS DOCTOR LYKES	AMERICAN	11	49.1 N	27.8 W	12	21	35	5 NM	81	1018.1	15.6	13.3	4	10	21	8	16.5
SS DOCTOR LYKES	AMERICAN	13	39.6 N	45.8 W	12	29	35	10 NM	02	1010.5	22.3	17.2	4	10	24	6	16.5
SS TILLIE LYKES	AMERICAN	14	45.6 N	26.5 W	06	20	M 40	5 NM	00	1005.1	15.6	13.0	6	8			
MV ATLANTIC FOREST	NORWEGIAN	14	36.2 N	65.6 W	18	25	M 33	2 NM	63	1012.0	24.7	24.0		13			
SS ZOELLA LYKES	AMERICAN	14	38.1 N	28.1 W	12	27	M 35	5 NM	02	1014.6	19.0	18.9	5	10			
SS AMER ALLIANCE	AMERICAN	15	53.0 N	18.2 W	06	16	35	5 NM	02	1009.1	12.7	12.7	5	10	14	9	11.5
SS TILLIE LYKES	AMERICAN	16	37.8 N	43.8 W	12	20	M 35	5 NM	01	1016.9	22.8	21.2	4	6.5			
SS SEATRAIN OHIO	AMERICAN	17	40.0 N	69.0 W	12	33	35	5 NM	02	1004.7	11.2	11.3	8	16.5	35	8	24.5
MV ARALUCK	NORWEGIAN	17	40.8 N	60.6 W	18	26	43	5 NM	21	998.0	20.0		6	8	25	6	11.5
USCGC BOUTWELL	AMERICAN	17	40.4 N	69.5 W	06	23	M 40	5 NM	80	1003.4	18.6	20.0	4	10			

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind			Visibility	Present Weather code	Pressure mb	Temperature °C		Sea Waves*		Swell Waves	
			Lat. deg.	Long. deg.		Dir. 10's	Speed kt					Air	Sea	Period sec	Height ft	Dir. 10's	Period sec	Height ft
NORTH ATLANTIC OCEAN		JUNE																
MV ARALUCK	NORWEGIAN	18	40.8 N	33.7 W	12	28		40	10 NM	01	1007.5	15.0	23.0	7	16.5	27	7	19.5
MV ARALUCK	NORWEGIAN	19	40.9 N	49.7 W	00	26		43	10 NM	15	1013.0	17.5	20.0	7	16.5	25	7	19.5
ESSO ZURICH	AMERICAN	21	46.4 N	06.8 W	12	02		35	5 NM	02	1023.0	16.7	16.8					
SS SACREMENTO	AMERICAN	21	37.3 N	43.1 W	12	05		42	1 NM	63	1015.9	18.3	20.0	5	11.5			
SS OVERSEAS JOYCE	AMERICAN	22	36.9 N	48.2 W	00	02		35	10 NM	03	1018.5	20.0	20.6	7	10			
SS MARSHFIELD	AMERICAN	29	51.8 N	22.3 W	12	29		33	10 NM	02	997.0	12.8	14.7	8	8	23	9	11.5
SS MARINE FIDDLER	AMERICAN	30	55.1 N	15.4 W	12	22	M	35	10 NM	18	1000.0	12.2	11.1	3	[illegible].5	22	>13	24.5
SS MARSHFIELD	AMERICAN	30	50.9 N	24.9 W	00	30		35	5 NM	02	1000.0	11.7	14.7	8	16	30	9	19.5
MV BELLA MAERSK	DANISH	30	60.0 N	26.5 W	18	34		35	10 NM	23	994.0	8.0		XX	23			
ATLANTIC B																		
USCGC MIDB	AMERICAN	28	55.6 N	51.4 W	18	33	M	38	10 NM	02	1013.8	4.8	8.3	7	14.5			
ATLANTIC C																		
USCGC MUNRO	AMERICAN	12	52.6 N	35.5 W	21	09	M	42	1 NM	01	1009.8	7.8	9.6	8	14.5			
USCGC MUNRO	AMERICAN	13	52.6 N	35.5 W	03	08	M	43	1 NM	61	1006.6	8.5	9.6	9	16.5			
USCGC MUNRO	AMERICAN	19	52.7 N	35.3 W	09	12	M	40	.25 NM	61	1010.0	9.9	10.5	4	6.5			
USCGC MUNRO	AMERICAN	23	52.7 N	35.5 W	00	21	M	38	1 NM	61	1016.7	10.1	11.1	6	11.5			
USCGC MUNRO	AMERICAN	29	52.7 N	35.5 W	12	30	M	40	5 NM	02	1005.9	8.3	10.7	7	16.5			
ATLANTIC D																		
USCGC CAMPBELL	AMERICAN	6	43.5 N	43.1 W	21	01	M	34	.5 NM	95	1010.2	13.2	17.8	8	10			
USCGC CAMPBELL	AMERICAN	7	43.3 N	43.0 W	06	35		41	2 NM	01	1010.1	14.9	17.8	8	13			
USCGC CAMPBELL	AMERICAN	13	43.6 N	41.7 W	21	30	M	38	5 NM	15	1002.6	15.0	18.3	7	13			
USCGC CAMPBELL	AMERICAN	17	43.3 N	42.3 W	03	24	M	37	10 NM	01	1007.9	16.1	17.1	7	8			
USCGC CAMPBELL	AMERICAN	18	43.4 N	43.2 W	21	20	M	38	5 NM	02	1010.7	19.0	17.4	8	8			
USCGC CAMPBELL	AMERICAN	19	43.6 N	42.7 W	09	24	M	39	5 NM	02	1013.9	15.6	17.4	8	11.5			
GREAT LAKES VESSELS																		
SS JOHN DYKSTRA	AMERICAN	16	47.2 N	90.2 W	12	06	M	35	5 NM	62		4.0	3.8		5			
SS J L MAUTHE	AMERICAN	24	43.6 N	82.5 W	06	29	M	38	5 NM	18		22.0	16.0					

\+ Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: These observations are selected from those with winds of 35 kt or higher. In cases where a ship reported more than one observation a day with such winds, the observation with the highest wind speed was selected. In cases where two or more observations had the same wind speed, the one at 1200 GMT or the one closest to 1200 GMT was chosen. If this method still did not break a tie, the one with the lowest barometric pressure was picked. The data for the Ocean Station Vessels are based on 3-hr observations. In a good many cases, the maximum wind speeds given in the U. S. Ocean Station Climatological Data tables are higher because these are based on the Summary of Day entries.

Table 9
U.S. Ocean Station Vessel Climatological Data, North Pacific

Ocean Weather Station 'NOVEMBER' 30°00'N 140°00'W **May and June, 1973**

MEANS AND EXTREMES

MONTH	DRY BULB TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	DEW-POINT TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	SEA TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	AIR-SEA TEMP DIFFERENCE (°C) MIN	DA HR	MEAN	MAX	DA HR
MAY	13.9	01 15	15.7	20.4	*2 03	9.0	11 15	14.2	21.5	30 03	14.7	*03 09	19.2	21.6	28 00	- 3.5	01 15	- .5	6.4	30 03
JUNE	17.2	01 15	20.0	23.2	16 05	10.3	14 18	16.0	19.9	23 06	18.9	*17 21	20.4	24.2	17 18	- 4.4	17 18	- .9	3.2	16 03

MONTH	PRESSURE (MB) MIN	DA HR	MEAN	MAX	DA HR	TOTAL CLOUD 0-2	3-5	6-7	8 & OBSC	LOW CLOUD 0-2	3-5	6-7	8 & OBSC	RAIN OR DRZL	SNOW	TSTM	VSBY <1KM **	WIND (KTS) ≥34	≥48	≥64	COMP OB DAYS	%OBS WITH PCPN	NO OF OBS
MAY	1014.8	14 03	1024.3	1031.6	04 09	14.4	14.9	40.9	29.8	28.8	14.0	30.7	26.5	18	18	0	0	0	0	0	28	7.4	215
JUNE	1018.0	24 12	1024.9	1032.9	*14 09	10.5	20.1	34.3	35.1	20.5	17.2	27.2	35.1	10	10	0	0	0	0	0	24	3.3	239

** VV-90-93 AND/OR W=4 COMP OB DAYS-COMPLETE OB DAYS

Wind

MAY — WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	1.2	4.5	1.2	.3	.0	.0	7.2	8.2
NE	1.2	9.0	16.0	2.9	.0	.0	29.1	12.5
E	3.1	10.8	1.7	.0	.0	.0	15.7	6.5
SE	1.9	4.7	.9	.0	.0	.0	7.0	8.3
S	.0	3.9	6.2	.5	.0	.0	10.2	12.6
SW	1.4	5.3	3.8	.0	.0	.0	10.6	9.8
W	.0	4.7	3.0	.0	.0	.0	7.7	9.5
NW	.6	2.6	.1	.0	.0	.0	3.3	5.2
CALM	9.3	.0	.0	.0	.0	.0	9.3	.0
TOTAL	19.6	45.1	32.6	3.7	.0	.0	100.0	9.3

NUMBER OF OBS	MAX WIND DIR	SPEED	DA HR	VECTOR SPEED	MEAN DIR	(DIR IN DEGREES)
215	050	29	31 1600	1.7	057	

JUNE — WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.4	5.5	5.4	.0	.0	.0	11.4	10.4
NE	.0	9.3	42.2	4.3	.0	.0	55.8	13.0
E	.0	3.0	2.2	.3	.0	.0	5.5	9.8
SE	.0	2.1	1.3	.0	.0	.0	3.3	9.4
S	.0	0.7	1.5	.0	.0	.0	2.3	9.1
SW	.0	4.4	1.4	.0	.0	.0	5.8	8.8
W	.0	1.3	.0	.0	.0	.0	1.3	6.1
NW	.0	.5	.0	.0	.0	.0	.5	7.4
CALM	7.9	.0	.0	.0	.0	.0	7.9	.0
TOTAL	8.4	33.1	54.0	4.6	.0	.0	100.0	12.2

NUMBER OF OBS	MAX WIND DIR	SPEED	DA HR	VECTOR SPEED	MEAN DIR	(DIR IN DEGREES)
239	050	36	02 0000	8.9	048	

Wave

MAY — WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	3.4	2.2	.4	.4	.0	.0	.0	.0	6.3
NE	5.7	22.4	3.0	.0	.0	.0	.0	.0	31.2
E	6.2	12.0	.4	.5	.0	.0	.0	.0	19.0
SE	2.3	.6	.0	.0	.0	.0	.0	.0	2.9
S	.4	5.7	1.3	.0	.0	.0	.0	.0	7.4
SW	1.2	4.4	2.5	.0	.0	.0	.0	.0	8.1
W	2.7	2.0	.5	.0	.0	.0	.0	.0	5.1
NW	4.3	4.8	.0	.1	.0	.0	.0	.0	9.2
IND	1.4	4.7	.0	.0	.0	.0	.0	.0	6.1
CALM	4.7	.0	.0	.0	.0	.0	.0	.0	4.7
TOTAL	32.2	58.9	7.9	.9	.0	.0	.0	.0	100.0

NUMBER OF OBS 214 IND-INDETERMINATE

JUNE — WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	3.0	8.9	2.0	.0	.0	.0	.0	.0	14.0
NE	6.1	29.5	16.2	1.7	.0	.0	.0	.0	53.5
E	3.0	3.4	.3	.0	.0	.0	.0	.0	6.7
SE	.8	2.3	.0	.0	.0	.0	.0	.0	3.4
S	3.7	4.3	.0	.0	.0	.0	.0	.0	8.0
SW	4.0	.8	.4	.0	.0	.0	.0	.0	5.3
W	.7	1.3	.0	.0	.0	.0	.0	.0	2.0
NW	.0	.3	.0	.0	.0	.0	.0	.0	.3
IND	1.7	1.3	.0	.0	.0	.0	.0	.0	2.9
CALM	3.8	.0	.0	.0	.0	.0	.0	.0	3.8
TOTAL	26.9	52.5	18.9	1.7	.0	.0	.0	.0	100.0

NUMBER OF OBS 236 IND-INDETERMINATE

MAY — WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	25.7	33.2	4.2	.0	.0	.0	.0	.0	63.1
6-7	2.8	6.1	2.8	.0	.0	.0	.0	.0	11.7
8-9	1.4	9.8	.9	.0	.0	.0	.0	.0	12.1
10-11	.9	4.2	.0	.0	.0	.0	.0	.0	5.1
12-13	.8	.9	.0	.9	.0	.0	.0	.0	1.9
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	1.4	4.7	.0	.0	.0	.0	.0	.0	6.1
TOTAL	32.2	58.9	7.9	.9	.0	.0	.0	.0	100.0

NUMBER OF OBS	MAX WAVE HEIGHT HGT	PER	DIR	TYPE	DA HR	IND-INDETERMINATE
214	5.0	13	090	SWL	07 18	(DIR IN DEGREES)

*ALSO OCCURRED ON PREVIOUS OBSERVATIONS

JUNE — WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	24.8	42.0	7.1	.4	.0	.0	.0	.0	74.4
6-7	.8	7.1	10.9	1.3	.0	.0	.0	.0	20.2
8-9	.4	2.3	.8	.0	.0	.0	.0	.0	3.8
10-11	.0	.0	.0	.0	.0	.0	.0	.0	.0
12-13	.0	.0	.0	.0	.0	.0	.0	.0	.0
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	.8	.8	.0	.0	.0	.0	.0	.0	1.7
TOTAL	26.9	52.2	18.9	1.7	.0	.0	.0	.0	100.0

NUMBER OF OBS	MAX WAVE HEIGHT HGT	PER	DIR	TYPE	DA HR	IND-INDETERMINATE
236	3.0	9	080	SWA	01 21	(DIR IN DEGREES)

For each observation, the higher wave of the sea/swell group was selected for summarization; if heights were equal, the wave with the longer period was selected; if periods were also equal, the sea wave was used

Table 10
Selected Gale Observations, North Pacific
May and June 1973

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind		Visibility	Present Weather code	Pressure mb	Temperature °C		Sea Waves			Swell Waves		
			Lat. deg.	Long. deg.		Dir. 10°	Speed kt				Air	Sea	Period sec	Height ft		Dir. 10°	Period sec	Height ft
NORTH PACIFIC		MAY																
SS PRESIDENT MADISON	AMERICAN	1	34.6 N	153.0 E	12	32	40	10	NN	02	1012.2	15.0	17.3	8	10			
MV ASIA ZEBRA	LIBERIAN	1	38.0 N	149.8 E	06	34	37	5	NN	03	1013.2	9.8	12.0	11	19			
SS GUAM BEAR	AMERICAN	1	37.2 N	126.5 W	00	35	51	10	NN	02	1014.6	13.3	13.9	8	19.5	36	>13	24.5
SS ST LOUIS	AMERICAN	2	33.3 N	161.2 E	06	32	N 35	10	NN	03	1014.5	15.0	17.8	10	18			
SS THURD MAERSK	DANISH	2	34.2 N	146.3 E	18	20	40	2	NN	81	1003.8	17.0	22.5					
SS CHICAGO	AMERICAN	2	35.9 N	177.4 E	18	28	38	10	NN	02	1010.5	14.5	16.7	6	10			
SS THURD MAERSK	DANISH	3	34.5 N	144.3 E	00	25	40	2	NN	42	1003.0	20.6	22.5					
SS PRES MCKINLEY (NEW)	AMERICAN	3	41.5 N	163.7 W	06	20	35	5	NN	40	1011.8	12.2	8.9	6	10	22	10	10
MV SKAUSUND	NORWEGIAN	3	43.3 N	158.8 E	00	25	35	3	NN	03	1007.5	6.0	3.0	8	23			
MV TURMALIN	GERMAN	5	13.4 N	97.1 W	00	11	35	10	NN	03	1010.0	28.0	2.9	7	13			
SS SUMMIT	AMERICAN	5	34.3 N	166.0 W	12	27	N 35	10	NN	03	1002.4	2.2	2.8	6	8			
SS PACIFIC BEAR	AMERICAN	5	34.9 N	161.5 E	00	20	N 38	5	Nn	50	1015.9	17.8	16.7		19.5			
SS CHICAGO	AMERICAN	6	35.4 N	158.1 E	06	05	40	5	NN	21	1018.9	14.2	17.8	6	13			
SS PACIFIC BEAR	AMERICAN	6	34.8 N	152.7 E	06	03	N 35	1	NN	52	1018.0	14.4	17.2		10	09	X	23
SS CHICAGO	AMERICAN	7	35.1 N	149.7 E	00	03	35	10	NN	02	1028.4	16.7	20.5	5	5			
MV CHEVRON MISSISSIPPI	AMERICAN	7	37.9 N	149.3 W	18	03	35	10	NN	03	986.8	4.7	2.9	5	8	09	6	10
MV HONSHU MARU	JAPANESE	7	40.9 N	155.0 W	18	27	N 35	5	NN	02	1005.0	8.0	6.0	7	13	27	12	26
MV IMA	LIBERIAN	7	45.9 N	143.9 W	18	26	44	10	NN	16	1003.5	10.0	6.0	6	16.5			
MV TOYUTA MARU #1	JAPANESE	7	41.5 N	148.0 W	12	23	N 35	5	NN	02	1011.0	11.5	10.0					
MV WORLD PELAGIC	LIBERIAN	7	46.0 N	149.5 W	18	27	40	10	NN	01	1003.0	8.0	9.0	8	24.5			
MV IMA	LIBERIAN	8	45.7 N	144.7 W	00	26	48	10	NN	15	1004.0	8.0	4.0	8	23			
SS OREGON MAIL	AMERICAN	8	34.0 N	152.3 W	06	01	35	5	NN	03	988.5	5.0	0.0	2	5	24	8	11.5
SS ARCTIC TOKYO	LIBERIAN	8	53.7 N	178.1 W	18	33	N 36	.5	NN	86	1016.0	1.0	4.0					
MV WORLD PELAGIC	LIBERIAN	8	45.0 N	151.6 W	06	29	40	10	NN	02	1011.0	7.5	8.5	7	10	27	8	24.5
MV HONSHU MARU	JAPANESE	9	47.6 N	167.0 W	18	30	N 36	5	NN	02	1013.0	4.0	3.0	8	19.5	28	12	26
MV PACKING	LIBERIAN	9	32.1 N	169.1 W	12	27	N 35	2	NN		1001.0	6.0	4.0	6	16.5			
SS ARCTIC TOKYO	LIBERIAN	9	32.7 N	170.6 E	18	32	N 35	2	NN	21	1022.0	4.3	4.0					
MV WORLD PELAGIC	LIBERIAN	9	. 4 N	161.4 W	18	27	40	5	NN	02	1019.0	8.0	8.5	8	10	27	10	18
MV IMA	LIBERIAN	10	42.9 N	134.8 W	18	30	44	10	NN	89	1015.5	6.5	6.0	8	23	28	10	32.5
SS SUMMIT	AMERICAN	10	35.3 N	161.6 W	00	36	N 50	5	NN	76	1009.0	8.5	3.4	6	6.5			
SS ARCTIC TOKYO	LIBERIAN	10	30.0 N	163.5 E	12	24	N 42	.25	NN	63	1015.0	5.0	3.0					
MV WORLD PELAGIC	LIBERIAN	10	43.9 N	164.3 W	06	31	N 40	5	NN	02	1022.0	8.0	9.0	8	10	28	10	18
SS ARCTIC TOKYO	LIBERIAN	11	47.5 N	159.5 E	00	26	N 42	< 50	VD	47	1008.0	8.0	3.0					
SS PHIL MAIL	AMERICAN	11	48.6 N	130.7 W	12	34	33	2	NN	50	998.5	4.5	4.0	6	11.5			
MV IMA	LIBERIAN	11	43.7 N	155.5 W	00	30	47	10	NN	19	1017.8	6.0	6.0	8	23	28	10	32.5
SS SANTA MARIA	AMERICAN	11	30.8 N	139.0 W	06	14	35	5	NN	18	1009.1	6.6	3.8	6	11.5			
MV HOEGH HUSKETEER	NORWEGIAN	11	33.0 N	139.2 E	00	19	N 35	5	NN	02	1009.5	20.0	18.0					
SS ELMIRA VICTORY	AMERICAN	11	49.9 N	139.3 W	12	20	N 38	2	NN	51	1006.5	6.0	9.0	8	14.5			
MV ARCHANGELOS	GREEK	11	30.0 N	179.4 E	00	25	35	5	NN	81	1001.9	12.5	4.4	6	8			
SS ARCO PRUDHOE BAY	AMERICAN	12	38.3 N	149.6 W	00	06	35	5	NN	62	1012.8	6.3	3.4	4	5	09	7	8
SS ARCTIC TOKYO	LIBERIAN	12	41.1 N	147.2 E	12	23	N 45	5	NN	03	1015.0	9.3	5.0	10	13			
SS SUMMIT	AMERICAN	12	36.5 N	153.9 W	00	04	N 40	5	NN	60	1004.1	4.5	4.5	9	14.5			
SS AMER CHARGER	AMERICAN	13	49.3 N	143.6 W	06	10	33	2	NN	63	999.2	9.0	6.6	14	41			
MV YGUAZU	LIBERIAN	13	32.4 N	131.8 W	18	06	35	2	NN	58	999.0	4.0						
SS WASHINGTON MAIL	AMERICAN	13	34.4 N	130.5 W	18	09	30	10	NN	02	1007.5	6.5	5.5	4	6.5	09	12	6.5
SS MOBIL OIL	AMERICAN	13	33.7 N	143.4 W	18	08	N 36	5	NN	02	1003.4	5.3	5.6	7	13	12	10	16.5
MV ROSE	LIBERIAN	13	39.9 N	151.7 W	18	28	N 36	5	NN	01	1005.0	10.5	13.0					
MV YGUAZU	LIBERIAN	14	32.3 N	136.0 W	06	02	40	1	NN	58	996.5	2.0						
MV WORLD PRIDE	LIBERIAN	14	30.0 N	165.2 W	06	30	33	5	NN	02	1011.0	8.0	9.0	5	10	32	12	18
SS WASHINGTON MAIL	AMERICAN	14	34.8 N	134.0 W	00	07	40	10	NN	02	1005.8	6.1	5.0	4	6.5	09	13	10
MV ORIENTAL CARNAVAL	LIBERIAN	14	42.4 N	166.1 W	06	29	35	.5	NN	44	1004.1	7.0	7.7	6	13	32	9	14.5
SS PRES MCKINLEY (NEW)	AMERICAN	14	37.1 N	134.9 W	12	24	35	10	NN	25	1001.0	13.3	13.3	6	11.5	30	8	11.5
SS PRES JEFFERSON	AMERICAN	14	39.1 N	155.5 W	00	31	N 35	5	NN	02	997.0	7.8	8.7	8	16			
MV DONG HYUNG	KOREAN	14	51.3 N	155.1 W	00	36	38	5	NN	02	1000.5	5.0	5.0	7	13	02	8	16.5
MV WORLD PELAGIC	LIBERIAN	15	38.3 N	142.5 E	18	27	44	5	NN	02	1001.5	11.5	11.0	7	24			
MV IMA	LIBERIAN	15	40.6 N	173.2 E	12	23	38	5	NN	18	1004.5	14.6	11.0					26
SS OAKLAND	AMERICAN	15	37.5 N	136.2 E	06	32	45	5	NN	01	1000.3	13.0	13.6	7	13			
MV STARSTONE	LIBERIAN	16	14.0 N	98.8 W	00	03	37	10	NN	02	1010.0	29.0	30.0	6	8	30	11	13
MV SACRAMENTO VENTURE	LIBERIAN	16	40.0 N	178.1 E	00	22	N 35	.5	NN	45	1004.0	18.5	14.0	9	10			
MV IMA	LIBERIAN	16	40.3 N	170.0 E	00	23	40	5	NN	03	1000.4	13.0	11.0	5	16.5	21	7	19.5
MV EFFIE MAERSK	DANISH	16	14.0 N	98.0 W	06	33	34	10	NN	02	1014.0	26.0	32.0	8	11.5			
SS BRINTON LYKES	AMERICAN	16	30.9 N	132.8 E	06	13	45	2	NN	10	1000.3	18.8	24.5	6	8			
MV MIDAS RHEIN	LIBERIAN	17	52.6 N	140.3 W	06	20	N 40	1	NN	39	1012.4	6.0	4.0	13	16.5			
SS DAISHOWA MARU	JAPANESE	17	49.2 N	143.6 W	00	25	N 36	5	NN	01	1015.0	7.0	6.5	10	11.5			
MV TRIUMPH	PANAMANIAN	18	47.5 N	177.1 E	18	26	N 40	5	NN	02	1002.7	9.0	8.0	8	16.5			
SS PRESIDENT MADISON	AMERICAN	18	44.3 N	176.0 E	12	23	40	5	NN	02	1003.0	6.2	3.7	8	13			
MV MIDAS RHEIN	LIBERIAN	18	53.8 N	151.2 W	12	23	N 40	5	NN	03	1000.0	4.0	2.0	XX	19.5	23	12	24.5
MV MEDEA	SWEDISH	18	54.0 N	142.0 W	06	27	33	5	NN	01	998.0	4.0	5.0					
MV THOMAS G THOMPSON	AMERICAN	18	44.7 N	126.4 W	12	20	N 38	2	NN	07	1013.0	11.1	8.9	6	13			
MV ALMIRANTE	HONDURAN	18	14.0 N	93.0 W	12	36	33	> 25	NN	02	1013.9	27.3	29.8	6	6.5			
SS PHIL MAIL	AMERICAN	19	52.8 N	142.0 W	12	25	38	5	NN	03	1011.0	6.0	6.0	6	11.5			
SS HELSONVIK	NORWEGIAN	19	50.9 N	147.0 W	00	27	40	5	NN	80	1015.9	7.0	6.0	8	16			
MV TRIUMPH	PANAMANIAN	19	49.3 N	174.5 W	18	29	N 38	5	NN	01	1012.1	9.5	9.0	8	19.5			
MV MIDAS RHEIN	LIBERIAN	20	53.9 N	169.9 W	18	30	N 46	5	NN	02	1008.8	3.0	1.0	12	16.5			
SS PHIL MAIL	AMERICAN	20	54.0 N	137.0 W	18	27	35	5	NN	03	995.6	9.5	5.0	6	13			
MV TRIUMPH	PANAMANIAN	20	50.0 N	163.2 W	18	30	N 38	5	NN	01	1014.6	3.0	6.0	8	16.5			
MV MIDAS RHEIN	LIBERIAN	21	53.7 N	171.8 W	00	27	N 38	5	NN	01	1012.1	3.0	1.0	8	16.5			
SS PHIL MAIL	AMERICAN	21	53.8 N	162.0 W	06	31	38	5	NN	03	1015.0	4.0	4.0	6	13	29	6	16.5
MV ROSE	LIBERIAN	23	36.6 N	147.1 E	18	05	N 35	.5	NN	03	1015.0	9.0	20.0					
MV WINDFORD	LIBERIAN	23	45.7 N	143.2 W	17	29	N 40	5	NN	03	997.3	8.0	8.0		23			
MV TRIUMPH	PANAMANIAN	23	49.6 N	137.5 W	18	28	N 40	2	NN	50	971.2	6.0	10.0	8	16.5			
MV JANEGA	NORWEGIAN	24	50.5 N	143.0 W	12	27	38	> 25	Nn		997.0	5.0	5.0	3	10	26	8	16.5
SS GALVESTON	AMERICAN	24	33.4 N	136.2 W	06	14	33	1	NN	59	971.0	5.6	7.2	6	10	12	10	24.5
SS ARCO PRUDHOE BAY	AMERICAN	24	33.8 N	141.5 W	06	31	40	2	NN	60	973.0	7.0	4.4	14	29.5	36	>13	32.5
SS ARCTIC TOKYO	LIBERIAN	25	53.7 N	178.9 E	18	28	N 34	10	NN	06	1013.0	4.7	4.0	8	6.5			
SS SEALAND COMMERCE	AMERICAN	26	39.8 N	130.7 E	00	33	40	5	NN	01	1006.8	9.5	19.5	7	11.5			
SS ARCTIC TOKYO	LIBERIAN	26	53.6 N	173.6 W	06	27	N 38	.5	NN	43	1010.0	3.5	4.0	10	10			
SS HELSONVIK	NORWEGIAN	27	41.2 N	130.3 E	06	32	38	5	NN	01	1007.1	12.0	13.0	8	11.5	02	9	14.5
SS WASHINGTON MAIL	AMERICAN	27	41.1 N	151.7 E	00	33	45	2	NN	07	1003.4	9.5	12.9	14	19.5			

Vessel	Nationality	Date	Position of Ship Lat. deg.	Position of Ship Long. deg.	Time GMT	Wind Dir. 10°	Wind Speed kt	Visibility	Present Weather code	Pressure mb	Temperature °C Air	Temperature °C Sea	Sea Waves* Period sec	Sea Waves* Height ft	Swell Waves Dir. 10°	Swell Waves Period sec	Swell Waves Height ft
NORTH PACIFIC OCEAN		**MAY**															
MV JAPAN CADET	LIBERIAN	28	39.5 N	159.2 E	06	31	38	5 NM	02	1011.0	12.0	14.0					
SS GOLDEN GATE	AMERICAN	28	40.5 N	127.4 W	18	36	40	10 NM	02	1020.2	13.4	11.7	7	8			
SS WASHINGTON MAIL	AMERICAN	28	42.0 N	167.5 E	12	11	40	1 NM	10	1001.4	8.3	7.7	4	5	27	< 6	5
MV TRANSOCEAN TRANSPORT	PHILIPPINE	28	41.5 N	162.1 E	12	32	M 37	5 NM	02	1009.3	7.5	10.0	4	10			
SS SEATRAIN OHIO	AMERICAN	29	12.2 N	94.5 W	15	05	35	30 YD	82	1011.9	26.8	30.0					
MV SPINDRIFT ISLE	GERMAN	29	39.1 N	177.5 E	18	27	37	5 NM	02	1007.8	13.5	13.0	6	11.5	26	8	23
MV JAPAN CADET	LIBERIAN	29	39.9 N	164.9 E	00	31	36	5 NM	02	1012.5	11.0	12.0					
SS WASHINGTON MAIL	AMERICAN	29	41.9 N	171.1 E	00	27	33	1 NM	10	1000.0	10.7	12.3	4	5			
MV YAMA MARU	JAPANESE	29	38.0 N	176.7 W	06	20	M 36	2 NM	82	1007.5	16.5	14.0	6	10			
MV SPINDRIFT ISLE	GERMAN	30	38.1 N	178.9 E	00	32	40	5 NM	02	1014.2	13.8	15.0	6	11.5	26	8	23
SS LONGVIEW VICTORY	AMERICAN	30	39.0 N	175.8 E	00	32	M 36	5 NM	02	1013.9	11.7	13.3	7	10			
SS PHILLIPS OREGON	LIBERIAN	30	36.2 N	134.5 E	00	12	35	3 NM	51	1014.0	17.5	18.9	6	8			
SS PRES JEFFERSON	AMERICAN	30	37.1 N	157.6 E	18	20	M 33	5 NM	21	1006.8	17.8	18.2	6	8			
MV JAPAN CADET	LIBERIAN	30	39.9 N	174.7 E	06	34	36	10 NM	02	1016.0	13.0	14.0					
SS HONGKONG DELEGATE	LIBERIAN	30	37.1 N	126.1 W	06	36	35	10 NM	02	1017.6	11.0	14.3	8	13			
SS SANTA MERCEDES	AMERICAN	31	15.0 N	93.6 W	09	07	M 40	5 NM	02	1017.3	26.7	29.5	3	10	01	< 6	10
SS PRES JEFFERSON	AMERICAN	31	35.7 N	148.3 E	18	23	M 42	10 NM	03	1007.1	18.9	21.7	5	8			
SS PACIFIC ARROW	PANAMANIAN	31	37.2 N	130.0 W	18	12	M 38	5 NM	02	1021.5	19.0	14.4	7	11.5	34	7	11.5
SS GUAM BEAR	AMERICAN	31	36.8 N	128.3 W	18	35	51	10 NM	02	1018.3	12.8	13.6	8	19.5	36	>13	24.5
SS MILLYER BROWN	AMERICAN	31	38.6 N	124.6 W	12	35	40	5 NM	02	1010.3	11.2	11.7	6	23			
NORTH PACIFIC		**JUNE**															
SS AVILA	AMERICAN	1	40.0 N	125.0 W	12	34	33	2 NM	03	1012.0	11.7	8.3	3	6.5	32	12	24.5
MV TRIUMPH	PANAMANIAN	1	53.5 N	147.7 W	12	26	M 35	.5 NM	52	1012.2	5.5	8.0	8	16.5	26	8	19.5
SS MONTEREY	AMERICAN	1	34.2 N	127.2 W	00	34	39	10 NM	02	1015.9	15.0	16.1	5	8			
SS MILLYER BROWN	AMERICAN	1	38.3 N	126.3 W	18	35	42	5 NM	02	1018.2	13.0	11.1	8	16.5	01	8	19.5
MV VAN ENTERPRISE	LIBERIAN	2	42.7 N	154.2 E	12	30	M 35	10 NM	05	1006.0	8.0	9.0	8	13	30	8	16.5
MV TRIUMPH	PANAMANIAN	2	53.9 N	151.8 W	00	26	M 40	10 NM	02	1019.2	6.5	7.0	8	16.5	26	8	19.5
SS JOSEPH LYKES	AMERICAN	2	11.0 N	94.9 W	12	20	M 43 (A)	5 NM	64	1004.7	25.6	28.3	6	13			
SS MILLYER BROWN	AMERICAN	2	37.7 N	126.9 W	00	36	35	10 NM	02	1019.9	14.0	13.3	6	13			
SS FAIRSEA	LIBERIAN	2	39.3 N	124.1 W	12	33	M 35	10 NM	02	1011.0	12.0						
SS ARGYLL	BRITISH	3	39.0 N	123.9 W	18	34	33	5 NM	01	1013.1	10.5	9.0	3	8	34	>13	16.5
SS ARCO BAG RIVER	AMERICAN	3	39.6 N	125.2 W	12	36	33	10 NM	01	1016.0	11.0	7.7	10	18			
MV REGENT VANDA	PANAMANIAN	3	45.0 N	168.1 E	18	29	M 35	5 NM	03	1006.0	8.0	8.0	7	16.5			
SS AVILA	AMERICAN	4	51.7 N	139.3 W	06	18	35	.25 NM	45	997.6	8.9	8.7	4	10	22	7	19.5
SS ARGYLL	BRITISH	4	42.3 N	124.8 W	12	35	35	5 NM	05	1015.0	10.9	9.3	3	8			
MV REGENT VANDA	PANAMANIAN	4	45.0 N	170.0 E	00	30	M 37	5 NM	02	1009.0	5.5	4.0					
SS MONTEREY	AMERICAN	5	23.0 N	153.0 W	12	05	33	10 NM	02	1017.6	22.2	21.1	4	6.5			
SS MONTEREY	AMERICAN	6	25.2 N	151.5 W	00	07	35	10 NM	02	1021.7	22.7	24.4	4	6.5			
SS TRENTON	AMERICAN	7	35.0 N	142.0 E	00	09	45	1 NM	07	1003.4	19.4	21.1	5	10	09	< 6	13
MV IRISH STAR	IRISH	7	48.2 N	166.3 E	06	16	35	1 NM	61	1008.3	6.5	4.8	6	13			
SS MORMACGLEN	AMERICAN	7	39.8 N	152.5 W	00	23	33	5 NM	03	1015.9	17.2	14.4	5	8	24	7	11.5
MV STAR TARANGER	NORWEGIAN	8	41.5 N	146.9 E	18	09	M 35	.5 NM	10	1011.5	13.2						
SS TRENTON	AMERICAN	8	38.4 N	152.5 E	12	13	35	2 NM	50	1013.9	15.0	17.8	5	8			
SS HAWAII	AMERICAN	8	33.0 N	176.9 E	00	21	35	5 NM	02	1010.1	24.4	19.4	6	10			
MV LICA MAERSK	DANISH	8	37.3 N	123.2 W	12	32	35	> 25 NM	02	1014.1	13.2	13.0	6	8			
SS IBERVILLE	AMERICAN	8	30.9 N	133.0 W	00	04	M 35	10 NM	15	1024.7	19.5	19.5	8	6.5			
USMS FURMAN	AMERICAN	8	45.8 N	129.7 W	00	23	M 35	2 NM	61	1016.1	14.5	12.3	8	10			
SS PRES TAFT /NEW/	AMERICAN	8	47.8 N	165.8 W	18	23	35	1 NM	59	1011.9	18.4	12.8	7	13			
MV TOYOTA MARU #1	JAPANESE	9	41.9 N	178.2 W	00	07	M 41	5 NM	02	1016.0	10.5	9.0	5	10	10	12	23
MV SPINDRIFT ISLE	GERMAN	9	41.8 N	175.6 E	12	31	37	1 NM	55	1007.5	8.5	9.0	7	14.5			
SS SANTA MARIA	AMERICAN	9	40.9 N	125.7 W	18	36	40	10 NM	02	1022.7	17.8	12.2	8	10			
SS MONTEREY	AMERICAN	9	36.3 N	137.5 W	06	36	35	10 NM	01	1018.6	14.0	16.4	6	6.5			
MV SPINDRIFT ISLE	GERMAN	10	41.6 N	179.0 W	00	01	37	5 NM	01	1014.0	10.5	11.0	6	13	08	10	23
SS SANTA MARIA	AMERICAN	10	39.7 N	124.7 W	00	35	40	10 NM	02	1018.3	18.9	12.2	8	10			
MV TRANSOCEAN TRANSPORT	PHILIPPINE	10	37.6 N	124.5 W	18	32	M 40	5 NM	03	1014.9	13.9	14.4	5	14.5			
MV BUM WOO	KOREAN	11	46.9 N	148.0 W	18	31	40	.5 NM	50	999.5	10.0	8.0	6	8	32	10	10
SS FAIRSEA	LIBERIAN	11	51.6 N	130.7 W	18	13	M 38	5 NM	62	1010.0	12.0						
MV MONTIRON	LIBERIAN	11	48.0 N	133.3 W	06	17	M 40	50 YD	02	1000.3	11.0	1.1	8	13			
MV OMSHIMA MARU	JAPANESE	11	39.5 N	142.1 W	18	27	M 35	5 NM	02	1015.0	16.0	14.0	8	16.5			
MV NEW JERSEY MARU	JAPANESE	11	41.5 N	161.2 W	00	32	M 35	10 NM	02	1017.0	12.5	13.0	8	13			
SS PHILADELPHIA	AMERICAN	11	30.7 N	130.7 W	18	15	40	2 NM	69	998.6	11.1	10.6	8	16.5			
SS AVILA	AMERICAN	11	53.0 N	139.1 W	12	14	30	5 NM	03	997.3	6.1	5.6	5	11.5			
MV FENWOOR	NORWEGIAN	12	46.0 N	174.1 W	18	10	35	2 NM	63	995.0	7.0	10.0	5	8			
MV BUM WOO	KOREAN	12	46.9 N	148.7 W	06	31	38	.5 NM		1006.5	10.0	8.0	5	6.5	32	8	19.5
SS FAIRSEA	LIBERIAN	12	49.3 N	128.0 W	06	13	M 30	5 NM	63	1001.2	2.0						
MV IMA	LIBERIAN	12	46.9 N	137.4 W	18	28	30	2 NM	50	1000.5	8.2	9.0	10	16.5			
SS PHILADELPHIA	AMERICAN	12	30.4 N	129.2 W	06	15	40	2 NM	60	998.6	11.7	10.6	8	13	15	7	19.5
SS TRENTON	AMERICAN	12	44.9 N	175.0 W	12	12	35	5 NM	63	1009.1	7.7	6.7	8	8	12	< 6	8
MV IMA	LIBERIAN	13	46.5 N	138.6 W	06	29	35	2 NM	81	1008.5	9.0	8.0	12	23			
MV EASTERN MARINER	LIBERIAN	13	51.7 N	167.2 W	12	09	M 35	5 NM	58	990.0	5.0	4.5	8	8	09	8	13
MV MARITIME VICTOR	PANAMANIAN	13	49.4 N	166.7 W	12	11	36	2 NM	58	999.2	6.3	0.5	8	13			
MV MARY STOVE	NORWEGIAN	13	51.7 N	143.3 W	12	31	35	10 NM	03	1008.6	9.0	8.0					
SS AVILA	AMERICAN	13	46.8 N	131.4 W	00	28	35	10 NM	01	994.9	8.9	8.3	8	10			
SS TRENTON	AMERICAN	13	44.8 N	170.8 W	00	27	35	5 NM	02	999.0	8.3	6.6	4	5	23	6	13
MV JANEGA	NORWEGIAN	14	32.1 N	166.1 E	06	01	35	10 NM	03	1012.0	20.0	20.0	8	13			
SS CHEVRON FRANKFURT	LIBERIAN	16	37.3 N	159.5 E	06	19	M 35	10 NM	02	999.0	23.0	18.3					
SS C E DANT	AMERICAN	16	43.5 N	136.4 E	12	06	35	2 NM	21	997.3	11.7	11.7					
MV MIDAS RHEIN	LIBERIAN	16	42.0 N	150.5 E	18	35	M 40	2 NM	50	999.4	8.8	6.0	5	16			
MV PACIFIC PHOENIX	LIBERIAN	16	38.7 N	158.8 E	06	18	35	1 NM	51	992.0	20.0	19.0	12	24.5			
SS SEALAND TRADER	AMERICAN	16	45.2 N	160.0 E	22	09	35	2 NM	07	996.3	8.9	6.1	4	8	09	11	11.5
SS CALIFORNIA	AMERICAN	17	43.6 N	168.2 E	12	14	M 35	.5 NM	63	1008.0	9.4	7.8					
SS C E DANT	AMERICAN	17	45.1 N	160.5 E	00	07	35	.5 NM	45	997.3	10.0	9.6					
MV MIDAS RHEIN	LIBERIAN	17	42.7 N	153.2 E	06	35	M 45	1 NM	59	993.2	8.5	10.0	8	8	07	>13	16.5
SS SEALAND TRADER	AMERICAN	17	45.8 N	161.1 E	00	09	35	.5 NM	62	998.0	7.7	6.2					
USCGC NORTHWIND	AMERICAN	17	54.4 N	160.6 W	18	35	M 35	10 NM	01	1017.7	4.0	5.3	5	6.5			
SS JOSEPH LYKES	AMERICAN	18	26.7 N	149.8 E	12	25	M 38	10 NM	02	1009.1	26.7	27.8	10	16.5	27	>13	18
SS CALIFORNIA	AMERICAN	19	48.3 N	167.4 W	18	16	M 40	.5 NM	53	1010.8	6.7	6.7	4	8	16	7	11.5
SS CALIFORNIA	AMERICAN	20	49.6 N	158.5 W	12	10	M 35	10 NM	02	1013.2	8.1	8.1	4	6.5	16	6	10
MV TOYOTA MARU # 10	JAPANESE	20	43.0 N	174.3 W	00	20	M 38	.25 NM	61	999.4	14.1	9.5	7	16.5			
SS POLAR ALASKA	LIBERIAN	21	54.4 N	168.9 W	00	12	35	2 NM	81	990.0	6.0	6.0	8	10			
SS EXPORT CHAMPION	AMERICAN	22	17.0 N	101.4 W	18	36	40 (B)	200 YD	63	997.0	23.9	25.0	4	5	XX	X	16.5
SS PACIFIC ARROW	PANAMANIAN	22	48.4 N	137.9 W	12	16	M 36	.25 NM	62	998.5	10.5		7	8	16	8	13
SS VELMA LYKES NEW	AMERICAN	22	31.3 N	158.3 E	00	20	M 40	2 NM	61	1000.0	23.3	20.6	5	6.5	20	8	14.5
SS MOBIL OIL	AMERICAN	23	57.9 N	148.0 W	12	05	M 35	2 NM	07	999.7	9.5	8.9	4	10	06	8	14.5
SS LONGVIEW VICTORY	AMERICAN	23	39.7 N	138.5 W	06	22	40	5 NM	02	1007.8	15.6	15.5	8	14.5	22	10	16
MV LIECHTENSTEIN	LIBERIAN	23	40.7 N	145.0 W	00	23	M 35	2 NM	58	1003.5	14.0	12.2	8	13			
SS ARCO BAG RIVER	AMERICAN	23	55.2 N	144.9 W	12	14	35	10 NM	15	990.5	7.5	5.6	4	6.5	14	8	16.5
SS VELMA LYKES NEW	AMERICAN	23	29.5 N	149.5 E	00	23	M 44	10 NM	02	1001.0	25.0	21.1	5	5	20	6	13

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind		Visibility	Present Weather code	Pressure mb	Temperature °C		Sea Waves*			Swell Waves		
			Lat. deg.	Long. deg.		Dir. tens	Speed kt				Air	Sea	Period sec	Height ft	Dir. tens	Period sec	Height ft	
NORTH PACIFIC OCEAN		JUNE																
SS VELMA LYKES NEW	AMERICAN	24	26.7 N	141.5 E	00	22	N 42	10 NM	02	1003.7	26.1	24.4	5	6.5	23	6	10	
MV NEW JERSEY MARU	JAPANESE	27	42.3 N	166.9 W	12	18	N 37	50 VS	49	1010.5	12.0	12.5	9	16.5				
MV EISHIN MARU	JAPANESE	28	33.7 N	166.9 E	06	23	N 35	5 NM	03	1010.0	23.0	20.0	9	14.5				
SS HONGKONG DELEGATE	LIBERIAN	28	34.7 N	154.7 E	00	22	35	5 NM	64	1003.7	22.0	21.1	7	10	25	8	10	
SS GOLDEN GATE	AMERICAN	28	39.1 N	129.6 W	06	32	35	10 NM	01	1017.2	14.5	13.4	2	6.5	32	< 6	15	
SS FAIRSEA	LIBERIAN	29	39.1 N	124.0 W	06	33	N 35	5 NM	02	1011.0	13.0							
SS PRES JEFFERSON	AMERICAN	30	40.5 N	129.5 W	00	34	N 35	10 NM	03	1022.4	10.6	13.9	5	5	34	13	11.5	

* Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind
(A) Hurricane Ava
(B) Tropical storm Bernice

NOTE: These observations are selected from those with winds of 35 kt or higher. In cases where a ship reported more than one observation a day with such winds, the observation with the highest wind speed was selected. In cases where two or more observations had the same wind speed, the one at 1200 GMT or the one closest to 1200 GMT was chosen. If this method still did not break a tie, the one with the lowest barometric pressure was picked. The data for the Ocean Station Vessels are based on 3-hr observations. In a good many cases, the maximum wind speeds given in the U. S. Ocean Station Climatological Data tables are higher because these are based on the Summary of Day entries.

Rough Log, North Atlantic Weather

August and September 1973

ROUGH LOG, AUGUST 1973--This was a good month for mariners on the North Atlantic. Extratropical cyclones were near normal in number and generally weak, without good organization. The primary track in the western area was further south than normal, off the United States northeast and Canadian coasts, rather than across Quebec and Labrador Provinces. The storm paths across Canada into the Baffin Bay and Labrador Sea area were diffuse. On the eastern side of the ocean, the primary track was more northerly, passing into the Norwegian Sea, rather than eastward across Scandinavia.

There were two tropical cyclones--hurricane Brenda and tropical storm Christine. August is generally the second most prolific month for tropical cyclones. On the average, there will be about 2.4 tropical cyclones and 1.5 will develop into hurricanes. The largest number recorded in August was seven in 1933, followed by six in 1969.

The pressure pattern configuration was near normal, but pressures were more intense. The Bermuda-Azores High was near its climatological position, but the center was approximately 3-mb higher. A closed 1005-mb Icelandic Low was near 60°N, 30°W. A 1017-mb High was centered over northern Greenland. The pressure along the U. S. East Coast was normal. The pressure over the eastern Atlantic and Europe was 4 to 7 mb higher than normal. This higher pressure was compatible with the more northerly storm track in that area.

The anomaly chart was mostly positive, with a few exceptions. A negative 5-mb anomaly was centered with the Icelandic Low near 60°N, 30°W. It extended like waterwings to another negative 5-mb center over Bjørnøya Island in the Barents Sea, with another negative 4-mb center over the North Pole. Positive anomalies were centered over Hudson Strait (6 mb) and northern Greenland (5 mb). The largest positive center was 7 mb, over northeastern Europe. This large positive area stretched across the central Atlantic (30°N), and included Europe, North Africa, and the U. S. S. R. to 120°E.

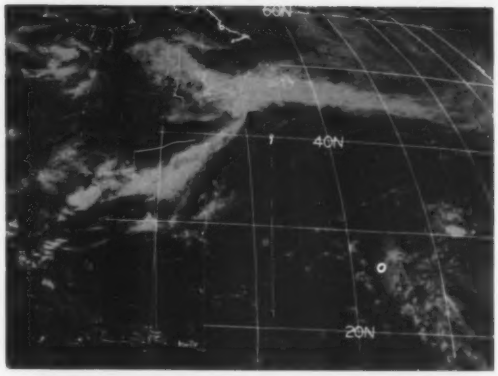

Figure 36.--Fronts which stretch due east-west in a straight line are a rarity. The western English coast, where the DONA MARIKA was driven aground in heavy seas, is just off the edge of the picture.

A general low-pressure area with several centers stretched along 60°N from southern Baffin Island to northern Scotland. On the 1st, a 1005-mb LOW was analyzed between Kap Farvel and Iceland. The circulation around this center spread,and, by 1200 on the 2d, the pressure was 997 mb, as the center remained quasi-stationary. A front extended across the ocean from England to Nova Scotia, approximately along the 46th parallel (fig. 36). Minor waves moved eastward along the front. At 1200 on the 4th, one wave developed enough to bring 35-kt gales to the ATKU, near 50°N, 20°W, and the EWAK, near 56°N, 15°W. Twenty-four hours later the FRANCE, headed west near 50°N, 28.7°W, was buffeted by 35-kt gales and light seas. The 11,478-ton Liberian tanker DONA MARIKA went aground at Milford Haven, England, in heavy seas, and was reported breaking up. She was abandoned safely by her crew of 38. At 0000 on the 6th, Ocean

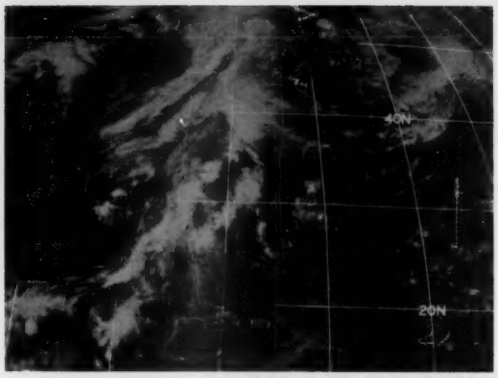

Figure 37.--The rapidly moving LOW is south of Cape Cod in this 1600 satellite picture. At this time, the cloud system of the storm is not well organized.

Station Vessel "C" was riding out 40-kt westerly winds on her port side, as the 986-mb LOW had drifted to 58°N, 19°W. By 0000 on the 7th, the LOW was absorbed by one of the waves moving around its perimeter and the combined system moved off to the northeast.

This LOW originated in northern Quebec on the 8th. It moved eastward and then made a sudden and swift shift to the south, to combine with a frontal wave on the 9th. At that time, the 1003-mb LOW was near Goose Bay. South of Newfoundland, the HOI ENDRECHT reported a thunderstorm and the JOHN CABOT was hounded by 35-kt gales. The LOW center tracked eastward and, at 1200 on the 10th, was near 54°N, 43°W, with a pressure of 993 mb. About 200 mi to the east, Ocean Station Vessel "C" measured 40-kt winds from the south at frontal passage. In almost a straight line south of Charlie, the AMERICAN ACCORD and the ATLANTIC CHAMPAGNE were tossed by 35-kt gales.

The center then turned northward and, late on the 12th, passed over Iceland. At 1200 on the 13th, the URYX, south of Iceland, reported being hit by 40-kt gales, as the storm took its last swipe at shipping before disappearing in the Norwegian Sea.

The genesis of this storm was in the midwest on the 14th. On the 16th, it moved off the coast and, by 1200 on the 17th, the 1009-mb LOW was at 42.5°N, 57.5°W. On the 19th, another LOW formed off St. John's, Newfoundland, and on the 20th the two combined. A ship was pounded by 45-kt winds near Belle Isle. At 0000 on the 21st, the RAEBURN was hit by 35-kt northeasterly gales, 200 mi northwest of the 988-mb center. Twelve hours later, Kap Farvel was blown by 40-kt gales. On the 22d, the LOW stalled near 58°N, 35°W and started to fill. On the 23d, another LOW approached from the south and absorbed the old center on the 24th.

The nemesis of sailors--Cape Hatteras--was the birthplace of this storm. A LOW developed early on the 22d and moved up the East Coast (fig. 37), deepening rapidly as it went. At 1200 on the 23d, the 1001-mb center was southeast of Nova Scotia. At 0000 on the 24th, the small, intense storm was over the Grand Banks and gale winds were reported in all quadrants. The SEDNETH and STIRLING BRIDGE were both lashed by 45-kt winds south of the center. The DART AMERICA, to the north, found 40-kt winds and the SEDCO, to the east, was pounded by 35-kt gales.

Twelve hours later, at 1200 on the 24th, the winds at the SEDCO's position had shifted almost 180° and increased to 45 kt. The ANSGARITOR, about 350 mi southwest of the center, was bounced by 40-kt northwesterlies, and the KOREA RAINBOW, about the same distance to the south, had 35-kt shifting winds as the front passed. Her location was very near the frontal occlusion.

On the 25th, the storm took a northward track, but much of its energy was sapped by other LOWS in the area. Another LOW, moving eastward out of Hudson Bay, would absorb this LOW. As it moved south of Kap Farvel, the FNJF, which had been stationary near 54°N, 55°W for several days, reported 40-kt gales.

This storm had the strongest winds reported in the North Atlantic this month. It formed a few miles south of the Newfoundland Coast on the 29th. It rapidly moved northeastward and, at 1200, the CETRA COLUMBIA and another ship reported 35-kt gales along the front. The 984-mb storm moved northeastward, and the IDE FJORD was rolled by 35-kt winds on her port side.

At 0000 on the 31st, the pressure had dropped to 980 mb, near 59.5°N, 35°W. The BUCCLEUGH had 40-kt gales. At 1200, the 976-mb center was at 61°N, 32°W (fig. 38). The DANA, near 63.5°N, 33°W, was washed by heavy rain blown by 50-kt winds. The FRIDA DAN, about 100 mi off Kap Farvel, and the MANCHESTER CRUSADER, about 200 mi further southeast, had 35-kt gales. Sea and swell were running 15 to 20 ft in the area. Six hundred miles to the southeast, Ocean Station Vessel "J" and the WEATHER SURVEYOR were

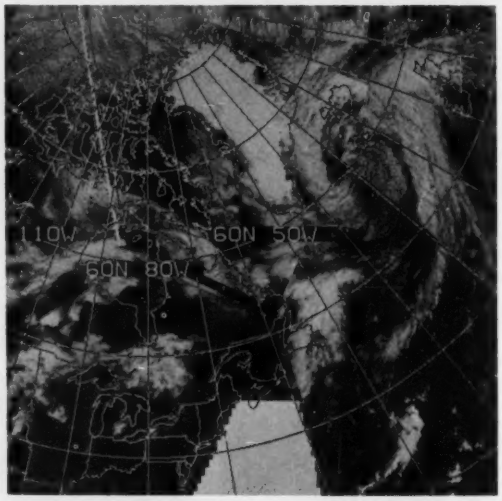

Figure 38.--The cloud system of this LOW is well organized compared with the storm in the previous figure. The DANA was sailing under the heavy clouds off southeastern Greenland.

both bothered by 35-kt winds near the front.

As the center moved just south of Iceland on September 1, the DANA still had 40-kt gales and 25-ft seas. The FRANCE I, south of the center, also found the 40-kt wind band. At 1200 that day, Ocean Station Vessel "I" bucked 35-kt gales and 15-ft seas to stay near station. The LOW continued northeastward until the 3d, when it stalled off the Norwegian coast and filled.

Brenda developed from a tropical wave that strengthened into a depression some 100 mi south of the western tip of Cuba, early on the 18th. She was heading west-northwestward. Brenda managed to reach tropical storm strength shortly before making landfall over the northern Yucatan Peninsula later the same day. Maximum sustained winds had reached 55 kt. Pressure was down to 992 mb. Several ships in the Yucatan Channel encountered 45-kt winds in 10-ft seas. Although the central pressure rose to 996 mb, Brenda managed to maintain tropical storm strength as she moved west-southwestward across northern Yucatan. Her center passed over the city of Merida on Sunday night--the 19th. Although the city recorded 45-kt winds, a 997-mb pressure, and was doused with torrential rains, there were no casualties and little damage.

Once Brenda moved over the friendly waters of the Campeche Bay, she began to intensify again. Early on the evening of the 20th, she reached hurricane strength some 60 mi west of Campeche, Mexico. Winds close to her 977-mb center reached 65 kt, while gales extended out 150 mi to the north and onto the coast to the south. The hurricane was moving toward the south-southwest. She continued to intensify as sustained winds reached 80 kt, with gusts to 100 kt. Tides of 5 to 10 ft above normal were pounding the southern shores of the Bay of Campeche. The 7,223-ton Greek freighter YUCATAN was anchored off the coast of Carmen. She flooded so fast that the 25-man crew was unable to launch lifeboats from the badly listing converted Liberty ship. They were forced to ride out the storm, which crossed the coast about 30 mi west of Carmen, early on the 21st. Carmen reported 45-kt winds, with gusts to 50 kt, while gusts reached 42 kt at Villahermosa (fig. 39), some 30 mi inland. Brenda continued inland and weakened as she moved into the Sierra Madre Mountains.

Figure 39.--The eye of hurricane Brenda is very near Villahermosa, Mexico, at 1532 on the 21st, where gusts of 42 kt were reported.

The Mexico City Weather Bureau reported that at least 10 people were killed. Two deaths occurred near Veracruz, five in Tabasco, and three in Campeche, where the town of Campeche suffered its worst flooding in a quarter of a century.

Tropical storm Christine was traced back to Guinea, on the African coast, on the 25th. She was tracked by satellite until the 30th, when the first reconnaissance plane was sent out and reported winds up to 45 kt in squalls. Christine had reached tropical storm strength 2 days before, near 10°N, 30°W. She was on a west-northwestward heading. As she neared the Leeward Islands on the 2d (fig. 40), winds rose to about 50 kt around a 996-mb pressure center. However, Christine deteriorated after that and crossed the northern portion of the Leewards as a depression on the 3d. The island stations lowest reported pressure was 1010 mb, and maximum sustained winds were about 25 kt. On the 4th, Christine was downgraded to a tropical wave, when reconnaissance aircraft were unable to find a wind center. However, gusty winds and heavy rains still existed in squall lines as tracked by radar on Puerto Rico. Gusts of 49 kt were recorded at San Juan Airport, and 45-kt gusts blew at Cape San Juan on the 4th. Over southeastern Puerto Rico, rains of 4 to 6 in were common. The greatest 24-hr amount was 9.52 in at Humacao, on the southeast coast.

Damage was restricted to some unroofed houses, blown-down sugarcane, banana, and plantain trees. Many streets were blocked by fallen trees. One person died when electrocuted by a fallen powerline.

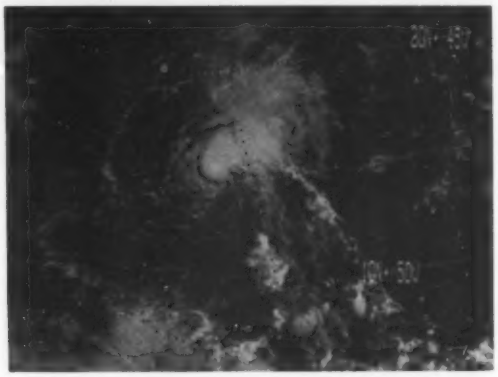

Figure 40.--An outer spiral band of tropical storm Christine is over the Leeward Islands on the 2d, while the center is approximately 300 mi to the east.

Casualties--A 28-ft cabin cruiser broke up and sank after hitting a jetty at Shinnecock Inlet on Long Island, in heavy seas and fog. Waves at the mouth of the inlet were reported to be 8 to 10 ft high. The British passenger liner CANBERRA (44,807 tons), with 1,800 passengers, dragged her anchors in a squall, and was

driven onto soft sand off St. Thomas, Virgin Islands. No damage or injuries were sustained.

ROUGH LOG, SEPTEMBER 1973--This was a near-normal month. The storm tracks followed the climatic pattern in a general way, as they were fairly diffuse. The two major source regions were out of Ugava Bay and the Gulf of St. Lawrence. The cyclone centers out of northern Canada and Ugava Bay generally did not track any further east than the Labrador Sea. The cyclone centers out of the northern United States and southern Canada that entered the Atlantic near Nova Scotia continued northeastward toward Iceland.

A secondary source of cyclone centers was off the northwest corner of Spain. Their direction of movement after forming was not consistent, except for a northerly and easterly component. Many of the cyclone centers were continuous in only the broad scale, as individual centers dissipated and reformed.

The mean sea-level pressure pattern was a rough carbon copy of the climatological pattern. The Azores High dominated the central and southern area. The Icelandic Low had two centers: one, at 1003 mb, in the Labrador Sea, and the other, at 1004 mb, between Kap Farvel and Iceland, near the climatological center of 1006 mb. The pressures and patterns over the eastern United States and western Europe matched the mean.

The largest anomaly--4 mb--occurred twice. A negative 4-mb anomaly center was near the 1003-mb low-pressure center, at 60°N, 50°W, and a positive 4-mb anomaly was centered off the African coast, near 30°N, 15°W.

September is noted for having the highest frequency of tropical cyclones of any month. An average of about three and one-third tropical cyclones can be expected, and two will develop to hurricane strength. This year, there were two: tropical storm Delia and hurricane Ellen. Since 1930, the largest number of tropical cyclones recorded for the month was seven in 1949. At least one has occurred every year, and in only 3 yr has none reached hurricane intensity.

The first significant North Atlantic storm of the month can be traced from the Lake of the Woods area of northern Minnesota. At 1200 on the 2d, it was a 997-mb LOW centered in Ugava Bay. The N. B. MCLEAN, near Cape Mercy, had 40-kt easterly winds. Twelve hours later, as the LOW moved into the Labrador Sea, Resolution Island experienced freezing 35-kt northerly gales and VGBZ (which I have been told is a drilling rig) also reported 35-kt gales, but from the southwest.

At 1200 on the 3d, the 978-mb LOW was near 60°N, 55°W. SEDCO I, far to the south, suffered 40-kt gales. By 0000 on the 4th, the LOW split into two centers, both 986-mb. The new center was near 55°N, 41°W. The DAWSON, northeast of Hopedale, was lashed by 60-kt winds. At 0000 on the 5th, the BESSTRA was whipped by 50-kt north-northeasterly winds near the same area.

By 1200 on the 5th, the original LOW, which had moved toward the south, had deteriorated to only a trough. The new LOW had swung northeastward and was also filling. At 0000 on the 6th, its pressure was 998 mb. To the south, a wave developed (fig. 41) on the

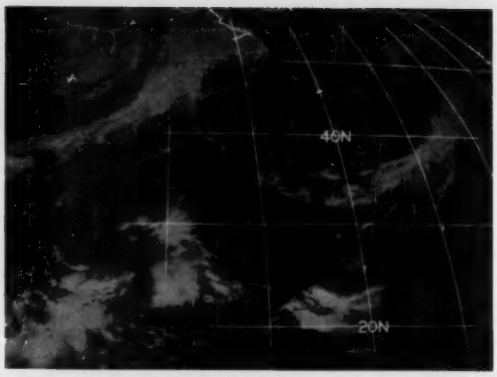

Figure 41.--By the time of this satellite picture, at 1645 on the 6th, the wave had become a well-developed LOW, near 50°N, 33°W. The cloud bands paralleling the wind flow can be seen as far west as Newfoundland.

front, near 45°N, 37°W, and the MANCHESTER QUEST, south of Argentia, was mauled by 50-kt winds. SEDCO I again registered 35-kt winds. As the LOW approached Iceland on the 7th, it could no longer be analyzed on the charts. The new wave was then developing, and the ATLANTIC CROWN was rolled by 35-kt winds on her starboard side. This LOW quickly developed, and faded just as quickly.

This cyclone developed as a tropical depression over the Yucatan Peninsula on the 7th. It moved across the Gulf of Mexico and crossed the Texas coast near Matagorda on the 11th (fig. 42). It then moved eastward and passed over Cape Charles late on the 14th. As the storm approached and passed over Texas, it drenched the coastal area.

At 1200 on the 15th, the 993-mb LOW was 200 mi southeast of Nantucket Island, and the QUEEN ELIZA-

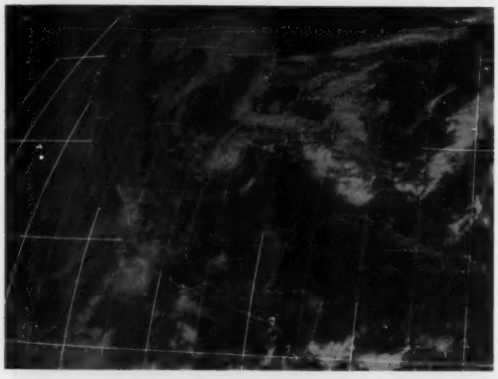

Figure 42.--The tropical depression attained a closed circulation on the 10th, becoming a tropical cyclone, and was over the Texas coast at 1445 on the 11th. As the storm moved eastward, it combined with a front and became extratropical early on the 14th.

BETH II was whipped by 45-kt gales near her center. The LOW sped along the Gulf Stream and was over the Grand Banks 24 hr later. SEDCO I was pounded by 45-kt gales as the center approached. The QUEEN ELIZABETH II was following behind the storm and still receiving 35-kt winds on her port side.

As the LOW moved more easterly, it crowded another LOW just south of Iceland, and Ocean Station Vessel "J" measured 45-kt headwinds. The seas were running 18 ft, and the swells 23 ft. As the storm moved south of the Iceland Low, it lost some of its punch and only left rain as it passed over England. On the 21st, it moved across the Baltic Sea, to be lost in Siberia.

A large, complex LOW was located over north central Canada on the 9th and 10th. At 1200 on the 10th, a new 989-mb center, north of James Bay, broke away and started to drift eastward. By the 11th, this new system (981 mb) had become the primary circulation, covering all of central and eastern Canada. As the LOW continued to develop, the front raced ahead of the center. The EWCS, near Sable Island, reported a roaring 50-kt wind. The CAPE BRETON MINER and VGBZ were both beaten by 40-kt gales.

As the LOW passed over the coast near Cartwright on the 13th, it split into several centers and moved northward in the Labrador Sea. On the 14th, the rocky coast of southern Greenland was its burial ground.

The cold front that extended toward the southwest out of extratropical storm Ellen lay in a trough between two HIGHs; one over the Azores, and the other near Quebec. At 0000 on the 26th, two waves formed on this front. The southern center of circulation, near 34°N, 63°W, was the one that would survive and harass shipping. By 1200, the pressure had dropped to 1004 mb. The NIENBERG, near 36.5°N, 51.5°W, was tossed by 40-kt gales and 12-ft seas.

By 1200 on the 27th, five ships were feeling the effects of this storm, with 35- to 40-kt winds and seas

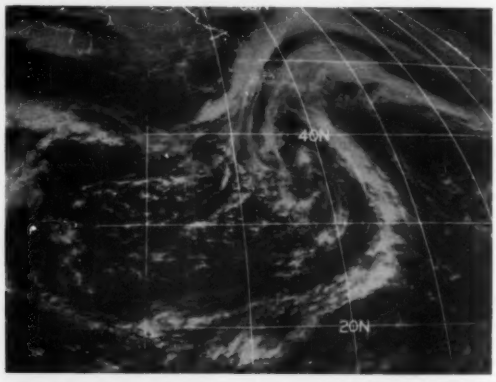

Figure 43.--The center of the LOW was near 36°N, 51°W, at the time of this ATS satellite picture. The associated frontal system had moved north and east of the center, with the point of occlusion near 45°N, 50°W. This was an odd case of the occlusion pointing toward the south, instead of the north, as usual.

running to 13 ft. They were the ADMIRAL CALLAGHN, CHRISTIAN MAERSK, CONTEST, TOCHIGI MARU, and an unidentified ship.

On the 28th, the Azores High bulged northward and, to the north, a LOW came out of Canada, blocking northward movement of the center located near 36°N, 53°W (fig. 43). The HOROMYA, within 60 mi of the center, battled 45-kt gales and swells of 23 ft. The LOW continued to be squeezed by the surrounding systems, but finally was able to start slipping northward. At 0000 on the 30th, the 995-mb LOW was at 51.5°N, 46°W. The QUEEN ELIZABETH II, southeast of the center near 49°N, 38°W, reported lightning and 35-kt gales. One hundred plus miles southwest of the QUEEN ELIZABETH II, the GALYA KOMLEVA was whipped by 40-kt gales and 20-ft seas.

At this same time, the HIGH to the east was moving northward and building. A LOW was also moving eastward out of the Gulf of St. Lawrence, and the gradient ahead of the front became very tight, although the winds did not become as strong as could have been expected. Ocean Station Vessel "C" and three other vessels measured 35-kt winds.

The now-small 993-mb LOW raced into the Denmark Strait, as if to hide from the more powerful bullies. It was to no avail--it could not withstand the combination of stresses.

This storm raced out of central Canada and across James Bay. By 1200 on the 29th, it was over the Gaspe Peninsula. The 993-mb LOW raised havoc with VGBZ, with 45-kt winds for the next 24 hr. The 987-mb center moved over St. John's, Newfoundland, early on October 1. The USCGC SHERMAN, south of Argentia, was whipped by 45-kt winds and 20-ft seas. Further south of the LOW, along approximately 41°N, the ATLANTIC CROWN and the ATLANTICA MONTREAL received 35-kt gales.

As the center moved over water, it turned north-northeastward. At 1200 on the 1st, the 988-mb center was at 52°N, 47°W. The VC 8062 was ravished by 50-kt winds and 25-ft seas. Twelve hours later, the LOW passed just southeast of Kap Farvel. Many miles to the south off the Grand Banks, the 5LBA was riding out 45-kt gales. As the LOW moved north into the Denmark Strait, the cold water rapidly sapped its energy.

On the 1st, a tropical depression formed in the Yucatan Channel just east of Cozumel Island. These are the same waters where Brenda had romped 2 weeks before. However, this depression moved toward the north-northwest, and developed into tropical storm Delia late on the 2d, near 24°N, 88°W. Winds of 45 kt blew around a 1000-mb pressure center. On Monday morning (3d), a reconnaissance report indicated Delia had strengthened during the night--winds had reached 50 kt. By late morning, Delia passed about 260 mi south of New Orleans, but was on a northwesterly course that was taking her toward the Texas coast. Highest sustained winds climbed to 60 kt and the pressure fell to 994 mb. That night and early the next morning, Delia's movement became slow and erratic. Now 60-kt winds roared around a 986-mb pressure center. In the evening (4th), the ill-defined center of Delia brushed the Texas coast near Galveston, where sea waves crashed and winds blew at 40 kt, with gusts to near 60 kt. Tides ran 5 to 7 ft

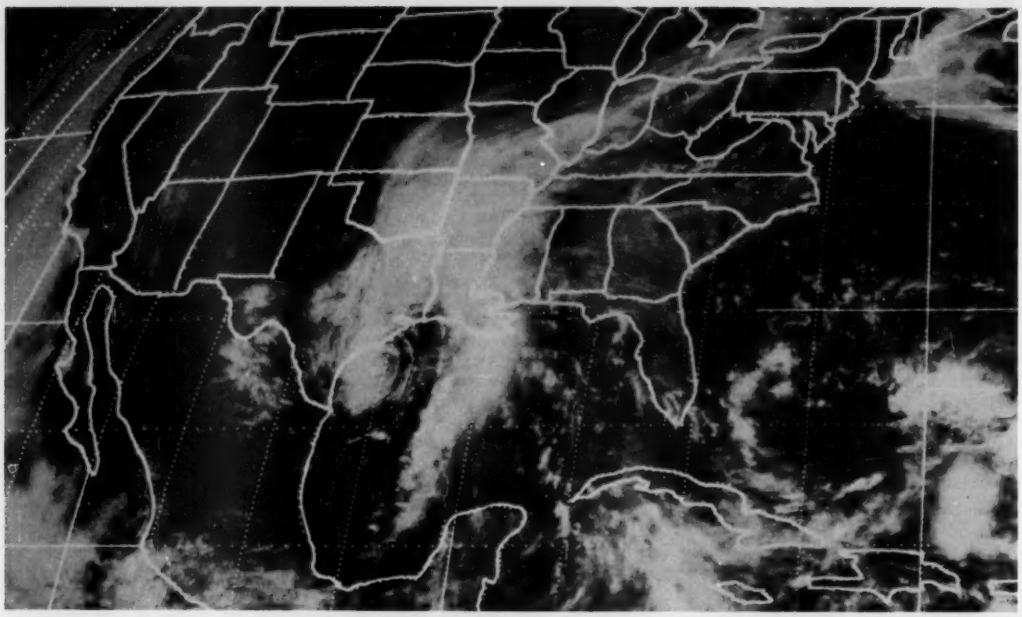

Figure 44.--Delia attained only tropical storm strength, as far as wind speed was concerned, but her heavy rain was devastating along the Texas-Louisiana coast. Delia is seen here at 1700 on the 5th, prior to moving inland.

above mean sea level in Galveston Bay; 6 1/2 ft at Baytown. Farther north at Sabine Pass, tides were measured at 4 1/2 to 5 1/2 ft above mean sea level.

Delia turned southward, looped counterclockwise, and went ashore just south of Galveston (fig. 44), late on the night of the 5th. She continued on a northwesterly course into south central Texas before making a gradual turn to the west-southwest, late on the 6th.

The greatest rainfall amounts associated with Delia occurred over southwestern Louisiana, where totals ranged between 8 and 10 in. Over southeast and east Texas, about 4 to 8 in fell, with amounts decreasing significantly as the storm moved across south central and southwest Texas. Six- to eight-in totals were common over Arkansas, while 3 to 4 in of rain fell on eastern Oklahoma.

Flash flooding was generally confined to southwest Louisiana and southeast Texas. Delia triggered four tornadoes, three in Louisiana and one in Texas; only one in northeast Louisiana caused damage, and it injured four people. Four deaths were reported during Delia. Two men were killed in a car accident on a rain-slick highway in Houston, and two youngsters drowned while playing near swollen bayous and drainage canals--one in Houston and one in Little Rock, Ark.

Damage caused by Delia was relatively minor. Property damage in residential areas of Baytown, Tex., was estimated at about $3 million. Coastal farmers suffered rice, cotton, and sugarcane crop damage along the upper Texas and southwestern Louisiana coasts; losses in the Beaumont-Port Arthur area alone were estimated at about $4 million.

Ellen was the most intense hurricane so far this season. As a hurricane she threatened North Atlantic shipping from the 19th through the 22d. She then turned extratropical and remained potent enough to become Monster of the Month. She came off the African coast as a tropical wave on the 11th. Four days later, Ellen became a tropical storm as she passed east of the Cape Verde Islands, on a west-northwesterly track. Ellen continued to chew up the miles without much further development until the 18th, when her pressure dropped below 1000 mb and winds climbed above 60 kt. Two significant changes occurred on the 19th. Ellen reached hurricane strength and began to swing northward near 27°N, 50°W. She continued to deepen. By the 21st, the pressure had fallen to 962 mb and winds had increased to 100 kt near her center. Ellen was at her peak (fig. 45), some 750 mi east-northeast of Bermuda. She was moving north-northeastward at 20 kt. On the 21st, the ELSFLETH encountered 35-kt winds, 180 mi southeast of the center. The following day, the LLLW battled 24-ft seas in 45-kt winds some 200 mi south of the center. Ellen was moving over cooler water. She became extratropical later on the 22d. Central pressure rose to 980 mb, but winds still blew at 95 kt, with gusts to 115 kt. The storm covered a large area. Gales extended 300 mi to the east and 200 mi to the west. Her strength was testified to by the CARCHESTER, early on the 23d, when that ship fought 40-ft seas in 50-kt winds some 200 mi southwest of the center.

Monster of the Month. Extratropical Ellen. Hurricane Ellen did not turn extratropical until the 23d, above

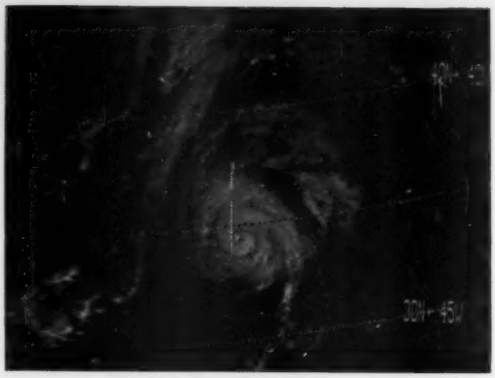

Figure 45.--Hurricane Ellen remained over water. She is shown here at her peak intensity on the 21st.

50°N. By 1200 on the 23d, the 984-mb center was near 54°N, 25°W. The WALTHER HERWIG was only 60 mi north of the center, and was pounded by 50-kt shifting winds and 20-ft seas. Ocean Station Vessel "C" and the QUEEN ELIZABETH II were treated to 40-kt gales.

By 0000 on the 24th, the pressure was down to 968 mb, when the center was west of Reykjavik. Ocean Station Vessels "A" and "I" both measured 40-kt winds, with "I" being bounced by 23-ft seas and 30-ft swells. The center moved over the Greenland coast at Angmagssalik. A report near 65°N, 27°W, off the west coast of Iceland, indicated 60-kt winds. Kap Gustav Holm reported 50-kt winds parallel to the coast. Gale winds were reported as far south as 50°N, between the longitude of Iceland and Kap Farvel.

The LOW moved southwest along the coast of Greenland and, at 0000 on the 25th, was over Kap Farvel. The pressure had increased to 978 mb. In the next 24 hr, Ocean Station Vessel "B" and the MURMANSK fought chilling 40-kt winds. During this 36-hr period, the following ships felt the wrath of this storm: Ocean Station Vessels "A," "C," and "I," the BURGENSTEIN, C. P. EXPLORER, CETRA LYRA, COTSWOLD, EUROFREIGHTER, HOHENLINDEN, and the MANCHESTER COURAGE. There probably were many others who either didn't report or whose reports were too late for plotting on the charts. Although tropical storms get much publicity, there were probably more ships involved with higher winds during the extratropical stage of this storm than the tropical stage.

On the 26th, the 984-mb LOW had circled and was again off Reykjavik. By this time, the gradient had relaxed, and only Ocean Station Vessel "B" reported winds as high as 40 kt. On the 27th, the LOW split into several centers and gradually disintegrated.

Casualties--The 887-ton Greek freighter KONDOR and the 10,931-ton Portuguese motorship H. CAPELOS collided in thick fog in the English Channel. This was a David and Goliath contest, but this time David lost. The KONDOR sank, with the loss of 10 of her 12-man crew. The H. CAPELOS was listing 12 degrees. Another collision occurred in heavy weather at Palermo on the 24th. The 12,869-ton CONCA D'ORO and LINDA 1 were involved.

Rough Log, North Pacific Weather

August and September 1973

ROUGH LOG, AUGUST 1973--Extratropical cyclone activity was below normal in the North Pacific this month. The primary climatological storm track from southern Kamchatka Peninsula to Seward Peninsula was closely followed by the actual tracks, but there were fewer storms. A second primary track from Japan to the Gulf of Alaska was further south than its climatological counterpart, which passes near the Pribilof Islands. The storms along this path were primarily late in the month, relatively few in number, and short-lived.

There were five tropical storms in the western North Pacific and one in the eastern North Pacific. In the west, there were typhoons Georgia and Iris, and tropical storms Hope, Joan, and Kate; in the eastern ocean, tropical storm Heather.

The shape of the mean pressure pattern was near the climatological normal. The average pressure was higher than the climatic normal over most of the area. One area over the Philippine Sea and the South China Sea was 1 to 2 mb below normal. The second and most significant area was 5 mb less than normal, centered near 53°N, 165°E, midway between the Near Islands and the southern end of Kamchatka. The ocean east of about 170°W averaged higher than normal. The highest departure was a positive 6 mb, centered near 45°N, 145°W. This was slightly northeast of the center of the 1030-mb High, located at 40°N, 150°W. A 1006-mb Low was centered near 55°N, 170°E, where, according to climatology, only a trough is present.

An interesting feature on the Northern Hemisphere 30-day mean and departure from mean charts was a 990-mb Low, resulting in a minus 12-mb anomaly centered north of Bangladesh over Tibet. Any effects on the North Pacific weather were not immediately apparent.

The Pacific was very quiet and, other than tropical cyclones, the storms were weak, not attaining winds higher than gale strength, according to the plotted weather charts.

This first "storm" was one of the few that produced gale winds. Its beginning was on the 1st, near 43.4°N, 166.5°W, at 1010-mb. The circulation was very weak until 1200 on the 2d. By 0000 on the 3d, it had moved northeastward to 54°N, 145°W, in the Gulf of Alaska, with a pressure of 1002 mb. At that time, the gradient indicated that it could support winds of 35 kt or greater, but none were reported until 1200 on the 3d, although there were ships in the area. The USCGC CONFI-

DENCE measured 35-kt gales off Sitka, Alaska. By the 4th, the LOW had passed inland over Cape St. Elias.

On the 7th and early on the 8th, the Bering Sea was an area of general low pressure. Two small 1010-mb LOWS were analyzed north of the outer Aleutians. By 1800 on the 8th, these had combined to a 1008-mb LOW near 54.3°N, 170.5°W. The center crossed the Aleutians into the Gulf of Alaska about 0300 on the 9th. It drifted slowly eastward and, at 0000 on the 11th, was near 56°N, 152°W. The DAIAN MARU was hit by 45-kt gale winds as she passed about 60 mi south of the center. The central pressure was then about 1012 mb and filling. Early on the 12th, the LOW was absorbed into the larger scale circulation.

This LOW formed over land just east of the Tatar Strait on the 21st. It moved rapidly across the Kuril Islands and had a 997-mb center near 47°N, 151°E, at 0000 on the 22d. As it turned northeastward and moved toward the Bering Sea, the TAIO MARU was hit by 35-kt gales along the front, near 42°N, 153°E.

At 0000 on the 23d, the 978-mb LOW passed northeast of Attu Island, which suffered shifting 40-kt winds as the center moved northeastward. Several ships in the area reported 30-kt winds.

Twenty-four hours later, the STAR ACADIA was tossed by 40-kt gales, with 12-ft seas and swells, near 53°N, 170°W. The 975-mb LOW was located at 59°N, 173°W. About 1200 on the 24th, the LOW moved inland near Hazen Bay, on the west coast of Alaska. Two shore stations, one on the Alaska Peninsula and the other on the Siberian coast, reported 35-kt winds. Ships in the Bering Sea were estimating 20- to 25-kt winds. The LOW turned northward and, as it crossed the Seward Peninsula, Uelen, on the Siberian side of the Bering Strait, reported chilling 40-kt winds, 36°F temperatures, and 100 percent relative humidity.

On the 26th, the LOW turned southeastward across the Alaskan Range. It was last identified near Valdez.

This LOW was exported from Nanking, China, at 1200 on the 27th. It moved across the Yellow Sea on the 28th and into the Sea of Japan on the 29th, with 1003-mb pressure. A significant amount of rain fell on northern Japan as the storm passed over on the 30th. The 16,079-ton FEDERAL NAGARA dragged her anchors and ran aground on muddy bottom in Inchon Harbor on the 29th.

It was not until September 1, when the storm had moved a considerable distance to sea, that gale-force winds developed. At 0000, the 996-mb LOW was at 45.5°N, 170°E, and the TATKAI MARU, at 45.9°N, 167.9°E, was headed northeast into 35-kt gales. Twenty-four hours later, the SEIHO MARU and the WEUI were blown by 35-kt winds in the southwest quadrant of the storm.

At 1200 on the 2d, the LOW reached its lowest pressure of 982 mb, near Atka Island in the Aleutians. The TATKAI MARU, which was following the LOW eastward, was hit by 40-kt winds on the 3d (fig. 46), and the PACIFIC PHOENIX had 35-kt gales 200 mi south of the center. She also contended with 15-ft swells.

As the LOW moved into the Gulf of Alaska, it was filling and no longer any concern to shipping. By the 6th, it had dissipated to a 1001-mb depression.

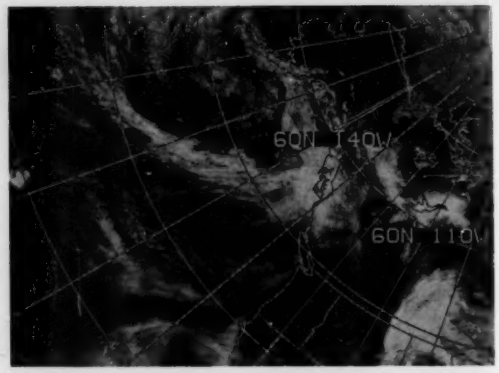

Figure 46.--The center of the LOW is near 51°N, 158°W, on the 3d. The cyclonic spiral cloud bands make it easy to locate the center. The associated front and its cloud shield are well ahead of the LOW.

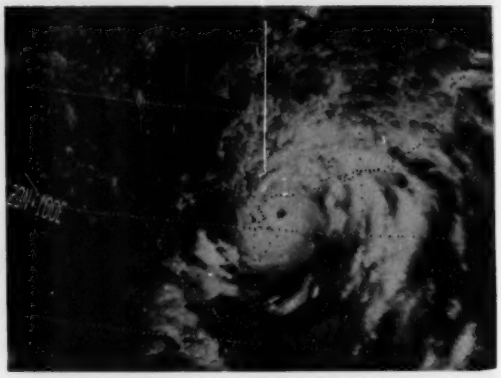

Figure 47.--Typhoon Georgia mauls Hai-nan and the Chinese coast, prior to moving inland on the 12th.

On the 9th, two tropical depressions more than 2,000 mi apart triggered Georgia and Hope. Both storms developed in areas not known for prolonged life. Georgia formed in the South China Sea, just inside the Luzon Strait, and Hope began just east of the Volcano Islands, near 20°N, 145°E. In these northern latitudes, Hope was only able to reach tropical storm strength. She moved northwestward, and, by the 12th, was a weak depression near 32°N, 150°E. Meanwhile, Georgia was on a westward course, developing rapidly. On the 10th, she was a typhoon, bearing down on Hai-nan with 65-kt winds. Georgia became the first of four tropical cyclones to maul Hai-nan during August and September. She struck the northeast coast of the island and turned northward. On the 12th, the typhoon moved onto mainland China near Tien Pai (fig. 47).

While Georgia and Hope were fading, typhoon Iris was budding near 22°N, 130°E, on the 10th. She was

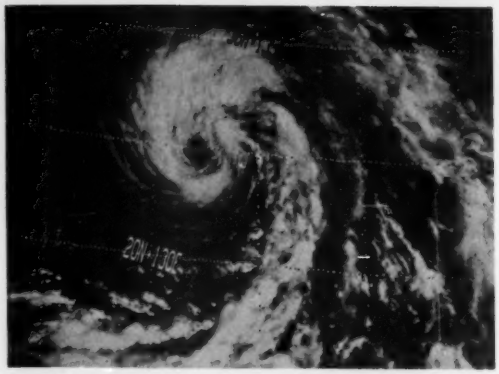

Figure 48.--Each individual tropical cyclone has its own characteristics. Typhoon Iris, on the 14th, has a large eye about 60 mi in diameter. The eye of typhoon Georgia was much smaller, about 10 mi in diameter.

quickly forced to tropical storm stage the same day, but then slowly matured while moving northward over the next 2 days. Iris blossomed into a typhoon on the 13th, about 150 mi south of Minamidaito Jima. Maximum winds reached 85 kt, with gusts to 125 kt. On the 14th, Iris turned northwestward toward the Ryukyu Islands (fig. 48). The following day she passed over Anamio Shima with minimum typhoon winds. Iris continued to go to seed as she traversed the East China Sea. On the 16th, she dropped to tropical storm strength and turned northward toward Korea. The next day, moving along the west coast of South Korea, she began to turn extratropical.

At 1200 on the 17th, Iris was just north of Seoul, Korea. A cold front with a wave was to the north in Manchuria. By 0000 on the 18th, Iris had moved northeastward and drawn the front into its circulation, completing the transition to extratropical characteristics, just south of Vladivostok. She then moved rapidly across Hokkaido. The 602-ton HOKUYO MARU was capsized off southern Hokkaido late on the 18th. One crewman clung to a tire tube for 14 hr before being rescued. At 1200 on the 19th, the 998-mb LOW was at 44°N, 159°E. The GLOMAR CHALLENGER, near 41°N, 154.5°E, was treated to 35-kt winds. Twelve hours later, the SILVER ARROW, near 41°N, 163°E, about 430 mi southwest of the center, also had 35-kt gales.

The LOW was then pushing against the stationary Pacific High, which was centered near 45°N, 152°W. It was a losing battle, and Iris was suffering from old age.

Joan came to life in the Philippine Sea--an area noted for developing supertyphoons. However, this baby barely reached tropical storm strength before petering out in the East China Sea. She was first sighted on the 18th, near 20°N, 130°E. Heading westward, Joan became a tropical storm on the 19th. By the 20th, she was through the Luzon Strait and weakening to a depression.

Four days later, Kate came to life just southwest of

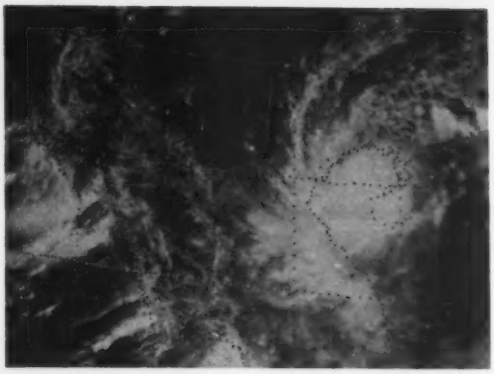

Figure 49.--Short-lived tropical storm Kate does not have a well-defined cloud-free eye, as she moves across the Gulf of Tonkin.

Hai-nan. She crossed the island as a depression, on a northwestward heading. The following day, on the 25th (fig. 49), Kate intensified to tropical storm strength as she emerged into the Gulf of Tonkin. From here, she headed westward, moving into North Vietnam late on the 25th.

A tropical depression developed into tropical storm Heather at 1800 on the 31st, after a period of development starting on the 29th.

The convergence zone was active along 8°N, 82°W to 10°N, 92°W and, at 0000 on the 30th, a large cloud mass, on satellite pictures near 13°N, 94°W, indicated that a disturbance had formed. The AMERICAN LIBERTY and the UNDEN reported pressures of about 1007 mb, and a cyclonic circulation near 13°N, 93°W was indicated.

No further reports were received until 1800 on the 30th, when the disturbance became a depression with a central pressure of 1004 mb, centered near 13.4°N, 94°W. The AMERICAN AQUARIUS, CHRYSALEMA,

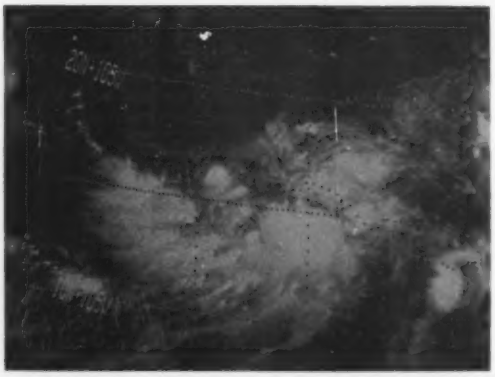

Figure 50.--Tropical storm Heather, south of Salina Cruz, Mexico, at 1600 on the 31st, appears as only a large cloud mass with feeder bands and a cyclonic circulation.

and the DAISHIN MARU were in the peripheral area.

The depression developed into a tropical storm after moving northwest to 15°N, 95°W, at 1800 on the 31st (fig. 50). The TEXAN and the non-AMVER vessel JFIL reported 30-kt winds between 30 and 45 mi southeast of the center.

At 1800 September 1, Heather was relocated near 15.5°N, 98°W, farther west than previous movement would have indicated. Reports from the CLARK-MAXWELL and the PEMEX C indicated a weak circulation. Three hours later, she was downgraded to a depression, and no further bulletins were issued.

Casualties--Other than the casualty mentioned in the text, only one other weather-related incident occurred in the North Pacific. Two Japanese freighters collided in fog on the 20th, off Cape Inubo. They were the 999-ton YUHO MARU and the 534-ton TOMOHIRO MARU. There were no injuries.

Three casualties occurred in the Indian Ocean. The NEPTUNE SAPPHIRE (12,000 tons), on her maiden voyage, broke in two in heavy seas 120 mi southeast of Durban. The 5,568-ton Singapore motorship PREMIER ARCTIC went aground on a reef in the Red Sea, during a sandstorm. The Liberian tanker FIDELITY (12,107 tons) buckled a forward plate in high seas off the horn of Africa.

ROUGH LOG, SEPTEMBER 1973--The first part of the month, the extratropical cyclone activity was below normal in number, but greater in size and intensity. During the last part, the cyclone activity was normal or slightly above normal, resulting in near-normal activity for September. The tracks followed the climatological pattern, in general, with two exceptions. The first was a secondary track from Japan to the Gulf of Alaska, which was south of the primary along the Aleutians. The second exception was a series of tracks during the middle of the month. The average path of these storms was between 40° and 45°N, toward the northern west coast of the United States.

The mean pressure pattern was also normal, with no major extremes. The 1022-mb Pacific High was only 1 mb higher than climatology, but had three subcenters, two of them further west than the primary center. The center of the 1005-mb Aleutian Low was 2 mb lower than the 1007-mb climatic center and collocated. The trough was sharper and slightly deeper. A small high-pressure center was located near Calgary, Alberta.

As in the Atlantic, when the data are near normal, there are no large anomalies. Again, in the Pacific, the largest anomalies were 4 mb. Two negative 4-mb anomaly centers were located south of Alaska along 50°N. The zero anomaly line approximately paralleled 40°N latitude across the entire Pacific. The area south to about 20°N latitude was positive, with several 4-mb centers along 30°N.

Tropical cyclone activity usually starts to decrease during September, from a maximum in August. Climatic records indicate that the western Pacific averages almost five tropical storms, and over three will become typhoons. In the eastern Pacific, mariners can expect three tropical storms, and about half will reach hurricane intensity. This month, there were two typhoons, Louise and Marge, in the western ocean, and in the eastern ocean, two hurricanes, Irah and Katherine, plus one tropical storm, Jennifer.

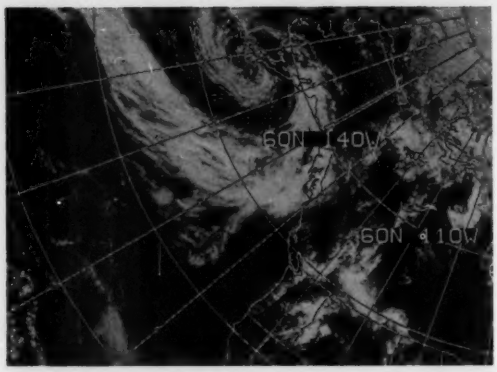

Figure 51.--On the 7th, the LOW is slightly south of the Alaska Peninsula. The frontal cloud band and triple point where gale winds were observed are many miles ahead of the storm's center.

This 1010-mb LOW had its start in the Sea of Japan, at 0000 on the 3d. As it moved across northern Japan, it slowly deepened. The storm was under the influence of the upper air zonal flow, and its pace was steady as it moved across the North Pacific at about 30 kt. By 1200 on the 5th, the 996-mb LOW was near 47.5°N, 172°E. It was not until 1200 on the 6th that it developed significant winds. The LOW was near 54°N, 167°W, over the Aleutians. The THOMAS E. CUFFE, 800 mi to the south along the front, was hit by 40-kt gales. The seas had picked up to 16 ft.

The storm's center moved up the Aleutian Island chain (fig. 51) and, at 0000 on the 7th, three ships reported 35-kt gales in the vicinity of the triple point, but only the HOTAKA MARU was identifiable.

On the 8th, the storm moved south of Kodiak Island. The IRISH STARDUST, at 50°N, 157.5°W, found winds of 45 kt about 400 mi south of the center. Later in the day, the G. B. REED, just off Vancouver Island, was fighting 35-kt southerly winds. The storm occupied all of the Gulf of Alaska, but was beginning to deteriorate rapidly as a HIGH moved eastward.

This LOW formed on the same front as the previously described LOW, over Kyushu, Japan, on the 6th. The incipient wave passed south of Tokyo on the 7th. As it moved over the Kuroshio Current, it rapidly deepened to 999 mb. The TAICO MARU, which was directly in the path of the oncoming storm, had 35-kt crosswinds. Twenty-four hours later, the 989-mb LOW was at 45.2°N, 161.3°E, and the KOYU MARU and the NELSON MARU found 40-kt winds both ahead and behind the storm. Twelve hours later, at 1200 on the 9th, the NELSON MARU was still being hit by 40-kt winds, but now out of the northwest, 180° from the previously reported direction. On the 10th, the JUZAN MARU was directly south of the center, with 40-kt gales accompanied by 23-ft seas and 26-ft swells.

This LOW also tracked up the Aleutian Island chain, but slightly on the Bering Sea side. It reached its

lowest pressure of 976 mb on the 11th. From this time on, it was downhill for the LOW, as it turned northerly toward the Bering Strait and filled. At 0000 on the 12th, the PHILIPPINE MAIL and the THOMAS G. THOMPSON, west and east of the center respectively, found opposite-direction 40-kt winds. The LOW passed over Mys Chaplina on the 13th, a 998-mb nobody.

This LOW was the grandmother of the LOW that produced the highest winds plotted on the weather charts for the North Pacific this month. How about that as a distinction? On the 8th, a frontal wave formed in the East China Sea. It moved northeastward through the Sea of Japan and the frontal wave occluded. At 1200 on the 11th, a new 998-mb LOW formed at the triple point which was now northeast of Hokkaido.

This new LOW crossed the Kuril Islands and moved parallel to the coast of the Kamchatka Peninsula. At 1800 on the 12th, a 992-mb grandchild was born near 50°N, 168°E. By 1200 on the 14th, the LOW was near 55.5°N, 178°W, and the pressure was at its minimum of 969 mb. It was at this time that the OHMINESAN MARU, near 59°N, 176°W, was whipped by 60-kt winds and heavy rain. The USCGC BURTON ISLAND was north of Unimak Island and had 40-kt gales with thunderstorms and lightning. Gale-force winds were reported all along the island chain. Late on the 16th, the LOW stalled south of Nunivak Island and lost its identity.

This small frontal wave, which developed south of Shikoku, Japan, on the 18th, originally could have almost been a figment of the analyst's imagination or a bump of his arm. A few hours later, though, there was no doubt of its reality as it developed and sped eastward. On the 19th and early on the 20th, ships were finding minimal gale-force winds east of Tokyo. At 1200 on the 20th, the 1000-mb LOW was near 39.2°N, 168.3°E. About 300 mi south, the IVAN KOTLYAREVSKIY was headed west fighting a 45-kt wind on her bow.

On the 21st, the LOW, now 984 mb, was moving over and being nurtured by the Kuroshio Extension Current. It was also under the influence of the long-wave zonal flow. Northwest of the center, near 44°N, 175.5°E, the OYO MARU was churned by 40-kt north-northeasterly winds and 20-ft easterly swells. To the south, the GLOMAR CHALLENGER also found 40-kt winds from the southwest, but calmer seas. The storm then turned northeastward and, at 0000 on the 22d, the DELTA DRECHT combated 50-kt southeasterly winds and 20-ft swells on her easterly course. Twelve hours later, the storm was at its lowest pressure and tightest gradient, but no ships were plotted in its zone of influence.

As the LOW moved into the Gulf of Alaska, it passed directly over Ocean Station Vessel "P," about 0800 on the 23d (fig. 52). It was losing some of its strength, and the maximum winds plotted were 35 kt. Late on the 24th, it moved onto the State of Washington coast.

This storm was another of those that develop from a combination of LOWs. One moved out of China, across the Yellow Sea and Korea, and was in the Sea of Japan on the 26th and 27th. Vladivostok experienced 35- to 40-kt winds for over 24 hr.

Another LOW had developed south of Japan and

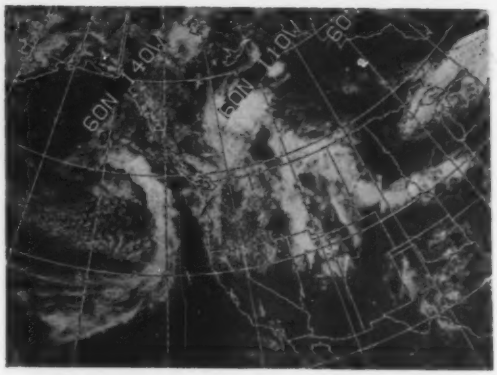

Figure 52.--The center of the LOW has just moved east of Ocean Station Vessel "P," and the front is approaching the West Coast.

appeared to be headed eastward, but on the 25th turned toward the north. It was treating ships to 35-kt gales on its east side. At 1200 on the 28th, the two LOWs combined off the Kamchatka Peninsula. The SHIKISHIMA MARU, in the Bering Sea, was hit by 35-kt gales. By 0000 on the 29th, the pressure had fallen to 982 mb off Mys Olyutorskiy. As the main center continued its northerly track toward the Bering Strait, other small LOW centers developed in the major trough. At 0000 on the 30th, the Pribilof Islands were whipped by 40-kt winds. The MONTIRON, north of Dutch Harbor, was roiled by 45-kt winds and 20-ft seas on her port side. South of Adak Island, the JAPAN ERICA was washed by heavy rain and 35-kt winds. As the 978-mb LOW moved into the Chuckchi Sea on October 1, a weather station on Mys Navarin was beaten by 50-kt winds. Uelen, on the Bering Strait, suffered 40-kt northwest winds and snow. The LOW continued into the Beaufort Sea and finally turned southeast into the Northwest Territories of Canada.

Louise popped up as a tropical storm in the Luzon Strait on the 3d. She meandered westward and climbed to typhoon strength on the 5th (fig. 53), near 20°N, 115°E.

Figure 53.--Hai-nan is about to be battered again, this time by typhoon Louise. In this picture on the 5th, Louise has attained typhoon-strength winds. Prior to hitting the island, her winds gusted to 100 kt.

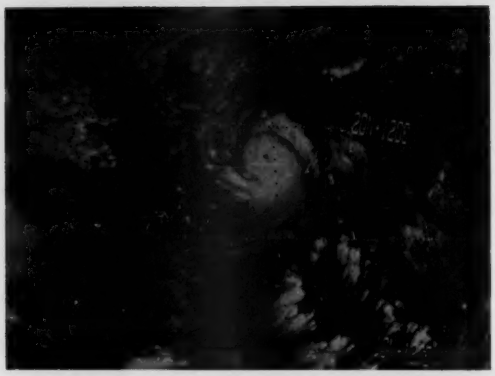

Figure 54.--Typhoon Marge followed closely behind Louise, on the same track over Hai-nan into the Gulf of Tonkin.

Louise was heading for Hai-nan. Before reaching the island, maximum winds near her center climbed to 80 kt, occasionally gusting to 100 kt. Louise weakened as she crossed the northern part of Hai-nan. She entered the Gulf of Tonkin as a tropical storm. On the 7th, she crossed the Gulf and made landfall over North Vietnam, just north of the 20th parallel.

Five days later, Marge came along, just west of the Lingayen Gulf in the South China Sea. Like a bear seeking honey, Marge headed toward Hai-nan. She reached typhoon strength on the 13th (fig. 54), as her winds climbed to 85 kt. Gales extended out about 100 mi. She crossed the Hai-nan coast that same day. The island took its toll, and Marge dropped to tropical storm strength shortly after emerging into the Gulf of Tonkin. She crossed the North Vietnam coast near 20°N late on the 14th.

Hurricane Irah began as a tropical disturbance near 13°N, 97°W, at 1800 on the 20th. Showers and squalls were reported the previous day, and the NANCY LYKES estimated 35-kt winds several degrees north of the center of a large mass of clouds. Westward movement of about 10 kt was indicated by ship reports and satellite pictures, as the disturbance became more organized.

Tropical depression stage was reached by 1800 on the 21st, near 13°N, 101°W, with the center turning northwestward. Tropical storm intensity was attained by 0000 on the 22d, at 15°N, 104.5°W. Ships reporting near the developing system included the MAGELLAN MARU, MARCONFIELD MERCHANT, MEGUROSAN MARU, TUGELA, and a non-AMVER-listed vessel, URPH. Movement continued northwestward at 12 to 15 kt, but slowed to about 8 kt as it intensified to hurricane strength at 1800 on the 23d, with the HOEGH MALLARD, NAGARA MARU, OAKLAND, and the TUGELA reporting from points well away from the center.

A more northerly course was taken from the 24th (fig. 55) to the 26th, with winds increasing to 95 kt at 0600 on the 25th, after which weakening began. The Cypriot motorvessel MARIKA M., Los Angeles to Santos, had to proceed to the Mexican coast on manual steering after sustaining damage.

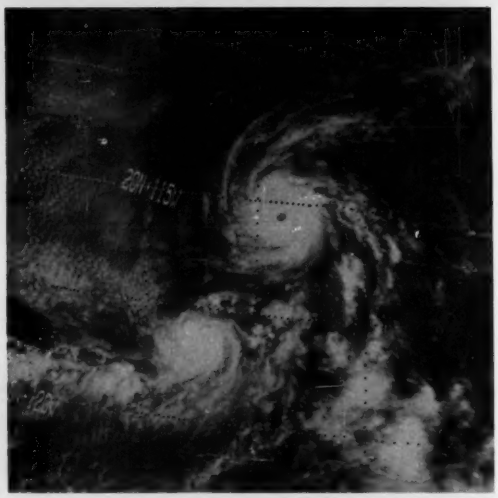

Figure 55.--Twin tropical cyclones, hurricane Irah and tropical storm Jennifer, were captured on this September 24 picture. Hurricane Irah moved northwestward, while tropical storm Jennifer, to the south, drifted to the northeast, toward Mazathan.

The hurricane moved across the Baja California Peninsula during the afternoon of the 25th, with 65- to 70-kt winds and heavy rain causing some power and communication line damage at La Paz. Further weakening took place during the night of the 25th, as the hurricane became a tropical storm, by 0600 on the 26th, with estimated 50-kt winds. By the time the storm moved onshore, about 30 mi northwest of Los Mochis, at 1600 on the 26th, it had weakened to 35-kt winds, with only light rainfall.

Tropical storm Jennifer began developing as a tropical depression near 13°N, 116°W, at 1200 September 23. The depression drifted eastward, south of Hurricane Irah, and slowly intensified until it became a tropical storm with 35-kt winds, near 13°N, 113°W, at 1800 on the 24th (fig. 55). No surface vessels were near the system, so its location and intensity were estimated from satellite pictures. Afternoon pictures indicated weakening and the storm intensity was lowered to depression stage, moving northwestward at 10 kt.

At 1200 on the 25th, the SANDVAAG reported a 1007-mb pressure and a 30-kt wind, about 40 mi from the center. This report was not available at map analysis time and suggested the tropical storm warnings should have been continued. At 1800, the TOYOTA MARU No. 18 and the non-AMVER-listed vessel 6MJJ located the center near 16.5°N, 109°W, moving northeastward at 10 kt. Reports at 0000 on the 26th from the HOEGH TRADER and the STATE OF MADYAPRADESH indicated the storm intensity had lowered to a tropical depression.

Local heavy squalls continued moving northeastward at 10 to 12 kt, brushing the Tres Marias Islands and moving onshore just southwest of Mazatlan, as

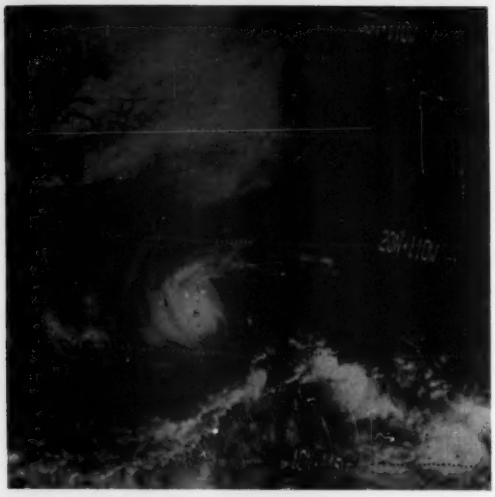

Figure 56.--Hurricane Katherine took pity on the Mexican coast. She formed further off the coast and moved toward the west, away from land areas. At 1638 on October 2, her eye is located near 17°N, 120°W.

indicated by reports from the BOSTON MARU, MARIAELISA, and the USCGC NORTHWIND, at 0600 on the 27th.

Squally areas of showers and thunderstorms developed about 400 mi south of Zihuantenejo on September 27, drifted westward and increased in activity on the 28th, and showed cyclonic circulation just north of Clipperton Island by the morning of the 29th. Satellite pictures at 1800 suggested intensification had continued, with development into tropical storm Katherine. The MOUNT PARK, southeast bound, north of the center, experienced 10- to 20-kt veering winds.

The storm moved northwestward at 12 to 15 kt, as it was followed in successive satellite pictures, due to a lack of ship reports near the storm. The SHEAF TYNE's reports on September 30 and October 1 indicated the presence of the storm, while 200 to 300 mi south of the center.

Infrared pictures at 0435 October 1 showed a well developed hurricane near 14°N, 116.5°W. The hurricane reached a maximum intensity of 85 kt near 16°N, 118°W, at 0000 on the 2d, and continued that strength (fig. 56) to near 17°N, 121°W, at 0000 on the 3d. Weakening began as the storm continued moving westward at 15 kt, becoming a tropical storm near 16°N, 127°W, at 0600 on the 4th.

The storm then moved west-southwestward at 10 to 12 kt, to 14°N, 140°W, when it was transferred to the Central Pacific Hurricane Center at Honolulu, at 1800 on the 6th.

The storm moved westward at 12 kt with winds of 40 to 50 kt through the 7th, weakening to 35 kt during the night of the 7th, and to a depression with 30-kt winds on the 8th. It dissipated near 14°N, 148°W, soon after 1800 on the 8th.

Vessels reporting from the periphery of the cyclone included the EXPORT BANKER, PIONEER, CONTENDER, TAKUYO MARU, and non-AMVER-listed vessels BLHD, FNAW, GLHF, and UNDK.

Casualties--The 1,569-ton Japanese freighter TOYOICHI MARU capsized and sank off northern Taiwan on the 29th, after being hit by high waves. The captain and three crewmen are missing. Seventeen other seamen managed to swim ashore.

One of two men who survived 72 days at sea, clinging to the overturned trimaran TRITON, died October 2. The trimaran capsized on July 11 in a gale, while enroute to Costa Rica from Tacoma, Washington. They were rescued by the British containership BENALDER (57,887 tons), on September 21, 900 mi southwest of San Francisco. The wife of the surviving man died 30 days after capsizing. They survived on canned sardines, peanut butter, and rainwater.

Marine Weather Diary

NORTH ATLANTIC, NOVEMBER

WEATHER. While normally November is considered a transitional period between fall and winter weather over northern waters, this month develops occasionally into the severest of the winter season. Most rough weather is confined to north of 45°N except along the coast of the United States where there is an increase in winter-type LOWS. Over the Great Lakes Region, two primary storm tracks--of Alberta and Colorado LOWS--converge into an area of maximum cyclone frequency, contributing in a large measure to rough weather toward the close of the Lake's navigation season. The Icelandic Low (1002 mb) is still centered between Iceland and southern Greenland. The Azores High has shifted eastward and is centered near 33°N, 29°W; its central pressure has risen slightly to about 1021 mb.

WINDS north of 60°N are quite variable at about force 3 to 4, although these winds tend to come from the northerly quarter west of Iceland and from the southerly quarter east of that island nation. Westerly winds, force 4 to 6, prevail over most of the ocean between 40° and 60°N. Between the latitudes of 30° and 40°N, force 3 to 4 winds are of variable direction except east of the Azores where a noticeable northerly component prevails. The "northeast trades," averaging force 3 to 4, extend from 30°N southward to 10° N. Between 10° N and the Equator, southeasterlies (force 3) are predominant.

GALES. The frequency of gales over northern and middle latitudes increases substantially in November. Winds of force 8 or higher occur 10 percent or more of the time over most areas north of about 35°N over western waters; north of about 40°N over the

central ocean; and north of about 44°N over eastern waters, including the southern half of the North Sea. A 10-percent frequency of gales is encountered on the Mediterranean only over the Gulf of Lions. Frequencies are generally less than 10 percent, however, over the waters between Iceland and southern Greenland (near the center of the Icelandic Low) and over a relatively small area about 200 mi northwest of the western Irish coast. Frequencies of 20 percent or more occur in the Davis Strait north of 63°N, south of Greenland in the vicinity of 55°N, 45°W, and over most of the Norwegian Sea.

EXTRATROPICAL CYCLONES. The principal track of extratropical LOWS is northeastward from the waters off Cape Cod, across Newfoundland to Iceland, and then through the Norwegian Sea. Sometimes these cyclones will approach Iceland from the central part of the North Atlantic Ocean. Other major tracks lead from Hudson Bay to the Davis Strait and from the Gulf of Lions to Italy.

TROPICAL CYCLONES are infrequent in November. Usually one storm in 3 yr may be expected. In the 42-yr period, 1931-72, 16 tropical storms occurred and 7 reached hurricane strength. Most of these storms develop over the Caribbean Sea or eastern Gulf of Mexico, and are soon following a northeasterly path out over the main body of the North Atlantic.

SEA HEIGHTS of 12 ft or more are encountered more than 10 percent of the time on most of the ocean north of about 40° N and south of the Davis Strait and the Norwegian Sea, and on the Mediterranean Sea in the Gulf of Lions and the northern Aegean Sea. The frequency increases to 20 percent or more over most of the waters between 47° and 60°N and over the Denmark Strait.

VISIBILITY less than 2 mi reaches a frequency of 10 percent north of a line drawn from the waters around Kap Farvel west-northwestward to Saglek, Labrador (55 mi northwest of Cod Island), and north of another line extending from Angmagssalik, Greenland, to northwestern Iceland, then across land to the Vesturhorn (eastern Iceland), then eastward to 64°N, 7°W; it then stretches north-northeastward across the Norwegian Sea to the waters north of Norway. An area of frequencies exceeding 20 percent or more lies north of Iceland between 67° and 72°N, eastward to about 5°W.

NORTH PACIFIC, NOVEMBER

WEATHER. November is often a stormy month north of 35°N over western waters and about 40°N over the eastern ocean. There have been years when November was the stormiest month of the winter season, but generally the weather is not too severe and there may be quiet periods lasting several days. South of 40°N, the probability of severe extratropical storms diminishes rapidly with latitude. During November, the Aleutian Low near 55°N, 176°W is well established over northern latitudes with a central pressure of 1000 mb. The Pacific Subtropical High, at 1021 mb, is slightly stronger than in October and is centered near 31°N, 145°W. Off the Chinese coast, pressures are higher than during October because of the buildup of the cold Asiatic High.

WINDS. Over the ocean north of 55°N, northerly winds (force 4 to 6) prevail, except over the eastern Bering Sea where winds are variable and the Gulf of Alaska where easterlies and northeasterlies are most common. With the exception of the area east of 140° W where southerly and westerly winds are prevalent, westerly winds (force 4 to 6) predominate between 55° and 35°N. Variable winds near force 4 are most frequent between 35° and 25°N, except over the Yellow Sea and waters off Japan where northerlies predominate. The northeast monsoon, affecting areas west of 140°E, and the "northeast trades" blow steadily at about force 4 south of 25°N. Lighter force 2 to 3 winds are the rule over the southern limits of the South China Sea, east of the Gulf of Siam. Northerly winds blow steadily out from the Gulf of Tehuantepec, off Mexico's south coast. They reach gale force between 5 and 10 percent of the time just west of the gulf.

GALES occur 5 percent or more of the time north of about 35° N. An area of 5- to 10-percent frequency is also found over the northern reaches of the South China Sea, including the Formosa Strait and the Luzon Strait, and west of the Gulf of Tehuantepec, as mentioned above. Actually, a frequency of 10 percent or more is found over most of the waters north of 35°N with the exception of the eastern Pacific east of 154°W (south of 50°N) and the waters east of the Kamchatka Peninsula. A small area of maximum frequency, where gales occur 20 percent or more of the time, is centered about 225 mi southeast of the southern tip of Kamchatka.

EXTRATROPICAL CYCLONES. The main storm tracks extend northeastward from the Japanese Islands to the western Aleutians and then east-northeastward to the Gulf of Alaska. Another primary cyclone track enters the gulf from an area in the central ocean near 47°N, 169°W. In November, there are more LOWS passing over the Gulf of Alaska than any other part of the Northern Hemisphere; this is also true of 5 of the following 6 months.

TROPICAL CYCLONES. On the average, two or three tropical storms develop over the western North Pacific in November. Two of these usually reach typhoon intensity. The region of most frequent formation is in the vicinity of the central and western Caroline Islands; the tropical cyclones either travel west-northwestward over the Philippines and the South China Sea or they recurve near 15°N, 132°E, to pass east of the Japanese Islands.

Tropical storm frequency over the eastern North Pacific drops rapidly for November, averaging about one every 2 yr. None have developed to hurricane intensity. During the 1956-72 period, one tropical cyclone occurred in the central North Pacific. When these late-season storms do develop in the eastern ocean, their direction of movement is usually more northerly than westerly.

SEA HEIGHTS of 12 ft or more are generally encountered 10 percent or more of the time within an area extending south-southeastward from Hokkaido to about 35°N and then eastward to 160°W. From there the line bounding the area travels north-northeastward to a point near 53°N, 142°W, and then westward across the Fox Islands and the Rat Islands to east-central Kamchatka. The Sea of Okhotsk is not included

within this very large area of frequencies greater than 10 percent. A small area of frequencies exceeding 10 percent is found over the waters surrounding Taiwan. A maximum frequency of 20 percent extends southeastward from the southeast coast of Kamchatka to about 44°N, 170°E.

VISIBILITY. Frequencies of low visibility (less than 2 mi) greater than 10 percent lie north of a line drawn from Mys Terpeniya, Sakhalin, eastward across the central Kurils and then north-northeastward to the waters east of the Komandorskiye Islands. From there the line stretches northeastward to St. Lawrence Island and the Seward Peninsula. Two smaller regions of 10 percent or greater frequency are centered over the Bering Sea near 54°N, 173°W, and over the midlatitudes of the eastern North Pacific near 46°N, 146°W.

NORTH ATLANTIC, DECEMBER

WEATHER. December is generally one of the stormiest months of the year over the North Atlantic, particularly north of 35°N. Deep and extensive LOWS traverse the middle and northern shipping lanes, producing strong winds and high seas. Extended periods of rain, sleet, or snow usually attend these storms. A comparison with the normal pressure pattern of the preceding month shows that in December the Azores High remains at about 1021 mb and is centered near 35°N, 33°W. The Icelandic Low deepens 1 mb to 1001 mb; it is located near 62°N, 38°W.

WINDS from the westerly quarter prevail over most of the ocean north of 40°N. Speeds average force 5 to 6 over most western and central waters, and about force 4 over the Bay of Biscay and surrounding waters, the Baltic Sea, and the southern portion of the North Sea. Force 5 to 6 southeasterlies prevail over the northern half of the North Sea, while southerlies of force 4 to 5 are predominant off the central coast of Norway. Winds over the Norwegian Sea are variable at about force 5. Between 40° and 30°N, winds (force 3 to 4) are westerly or southwesterly west of 20°W, northerly or northeasterly between 20°W and the Strait of Gibraltar, and predominantly westerly over the Mediterranean Sea. The "northeast trades," also averaging force 3 to 4, persist between 30° and 10°N, except off the east coast of Florida where winds are variable at force 4. As in November, force 3 southeasterlies prevail over the extreme southern North Atlantic.

GALES. The occurrence of gales is more frequent over northern and middle latitudes than in November. Winds of force 8 or higher occur 10 percent or more of the time from about 34°N over the western North Atlantic to about 40°N over eastern waters. A 10-percent frequency of gales is encountered on the Mediterranean Sea within an area extending nearly 200 mi southeastward from the Gulf of Lions. The incidence of gales is less than 10 percent over the immediate waters east of Newfoundland and over the Davis Strait. Areas of maximum gale frequency--20 percent or higher--are found within an area from the Labrador Sea southeastward to about 44°N, 35°W, then north-northwestward to 56°N, 40°W, then eastward to 55°N, 24°W, then north-northwestward again to the cold waters off southeast Greenland; over much of the Norwegian Sea; and over the Gulf of Lions.

EXTRATROPICAL STORMS. Two primary storm tracks--one from the waters east of the United States Middle Atlantic States and one from the northern Great Lakes--converge over Newfoundland and then head toward Greenland, where they split into two tracks with one leading into the Davis Strait and the other heading toward Iceland. A large number of LOWS also head toward Iceland from the central ocean east of 40°W and north of 50°N. Another cyclone track enters the Davis Strait from Hudson Bay, while still another runs across the northern coast of Norway from the Norwegian Sea. A primary track stretching from the Gulf of Lions to west-central Italy and then east-southeastward to the south coast of Turkey influences the Mediterranean area. The Great Lakes have their highest cyclone frequency of the year during December. The frequency of cyclogenesis over the Gulf of Mexico also reaches its annual maximum during December.

TROPICAL CYCLONES. There is seldom a tropical storm on the North Atlantic in December. During the 42-yr period, 1931-72, only two were recorded; one of these reached hurricane strength.

SEA HEIGHTS of 12 ft or higher occur 10 percent or more of the time north of a line extending from the northwest coast of Spain to approximately 35°N, 70°W, and then east of a line joining that point with Nova Scotia. On the Norwegian Sea, however, sea heights $\geq$ 12 ft usually occur less than 10 percent of the time. Ten-percent frequencies are also found in the Mediterranean between the Balearic Islands, Sardinia, Tunisia, and the French Riviera; between Sicily and Crete; and on the northern Aegean Sea. Maximum frequencies of 30 percent or more occur over the Denmark Strait and over much of the western and central ocean north of about 47°N and south of the 60th parallel. An isolated area of 20-percent frequency rests over the Gulf of Lions.

VISIBILITY. The frequency of visibility less than 2 mi climbs to 10 percent over the Labrador Sea, over a pocket-shaped area extending from Kap Farvel south-southwestward to the Grand Banks, over the southern and eastern Davis Strait, and over the southern North Sea. Frequencies of this low visibility are also greater than 10 percent over the area north of a line drawn from the Denmark Strait eastward across northern Iceland, then dipping southward to about 64°N, 7°W, then stretching north-northeastward over the Norwegian Sea, and then eastward to the northern coast of Norway. North of about 72°N, the frequency of visibility less than 2 mi increases to 20 percent and continues to increase as one moves eastward until, after reaching the southern Barents Sea north of the Soviet Union, frequencies reach a maximum of 40 to 50 percent.

NORTH PACIFIC, DECEMBER

WEATHER. December is usually a stormy month over North Pacific waters, particularly in the northern and middle latitudes. The normal pressure distribution is quite similar to that of the preceding month

with the Aleutian Low (1001 mb) shifting to near southeastern Kamchatka.

WINDS north of 55°N blow mostly from a northerly direction at force 4 to 6, except over the Gulf of Alaska where force 4 easterlies prevail. Westerly winds of force 3 to 6 are usually felt south of 55°N to about 40°N over the extreme eastern ocean, 35°N over the central-eastern and midocean, and 30°N west of 165°E and east of Japan. Nevertheless, winds over the southwestern Bering Sea show a tendency to be variable, and off the coast of British Columbia the prevailing wind is southerly. Steady "northeast trades" prevail (force 4) between 25°N and the Equator, except they extend to nearly 35°N off the southwestern California coast. These trade winds merge with the force 4 to 5 winds of the northeast winter monsoon near 140°E. Variable winds (force 3 to 4) lie in a narrow belt between the aforementioned westerlies and northeasterlies. Prevailing winds are largely from the north or northwest and average about force 4 over the Sea of Japan, and the Yellow Sea, and along the southeast coast of Japan. Northerly winds blow steadily out from the Gulf of Tehuantepec, off the south coast of Mexico.

GALES. A larger area of the North Pacific is subject to gales during December than in the preceding month. North of about 39°N over eastern and central waters and 32°N over western waters, 10 percent of the observations contain winds of force 8 or higher. The greatest frequencies, 20 to about 25 percent, occur in three scattered areas from the waters south of the southern tip of the Kamchatka Peninsula south-southeastward to about 34°N, 166°E. Farther north, the frequency of gales decreases to less than 10 percent over the Sea of Okhotsk and the Bering Sea. They are also under 10 percent across a triangularly shaped area southeast of the Aleutians bounded at 53°N, 162°W; 47°N, 163°W; and 49°N, 174°W. Gales are recorded between 5 and 10 percent of the time on the waters surrounding Taiwan, the southern Ryukyus, and the northern portion of Luzon as far east as 144°E, because of the strong development of the northeast monsoon. Gale-force northerly winds occur between 5 and 10 percent of the time out from the Gulf of Tehuantepec.

EXTRATROPICAL CYCLONES. Primary storm tracks extend from the northern portion of the Sea of Japan and the waters east of the Ryukyus to the ocean region lying between Kamchatka and the western Aleutians. From there, LOWS either pass near the Pribilof Islands or continue east-northeastward to the Gulf of Alaska. Another major storm track reaches the Gulf of Alaska from an area south of the Alaska Peninsula near 48°N. The only other primary cyclone track swings toward Vancouver Island from a point 450 mi west of the Oregon coast.

TROPICAL CYCLONES. One tropical storm usually develops over the western North Pacific during December. About two out of every three that do pop up go on to become typhoons. The most likely area of formation is in the neighborhood of the Caroline Islands. Contrary to the events of November, very few of these storms are able to maintain their identity over the South China Sea after traversing the Philippines.

Off the Mexican west coast, tropical cyclones are rare in December.

SEA HEIGHTS of at least 12 ft occur 10 percent or more of the time north of approximately 35°N, east of 150°E, and south of the Alaska mainland, the Aleutian Islands, Kamchatka, and 55°N on the Sea of Okhotsk.

VISIBILITY under 2 mi occurs 10 percent or more of the time north of a line drawn from the lower Tatar Strait to the central Kurils and then northeastward to the western Aleutians where it dips southeastward to about 47°N, 177°W. Upon reaching a point near 47°N, 165°W, the line bends generally northward to Cape Romanzof, Alaska. A much smaller area of 10-percent frequency is centered near 44°N, 143°W. Visibility less than 2 mi encompasses more than 20 percent of all observations poleward of a line cutting through the northern and eastern portions of the Sea of Okhotsk, the northern Kurils, and then northeastward through the Bering Sea to the Bering Strait (passing west of both the Komandorskiye Islands and St. Lawrence Island). A smaller area comprising a 20 percent or greater frequency lies north of the central Aleutians near 54°N, 173°W.

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